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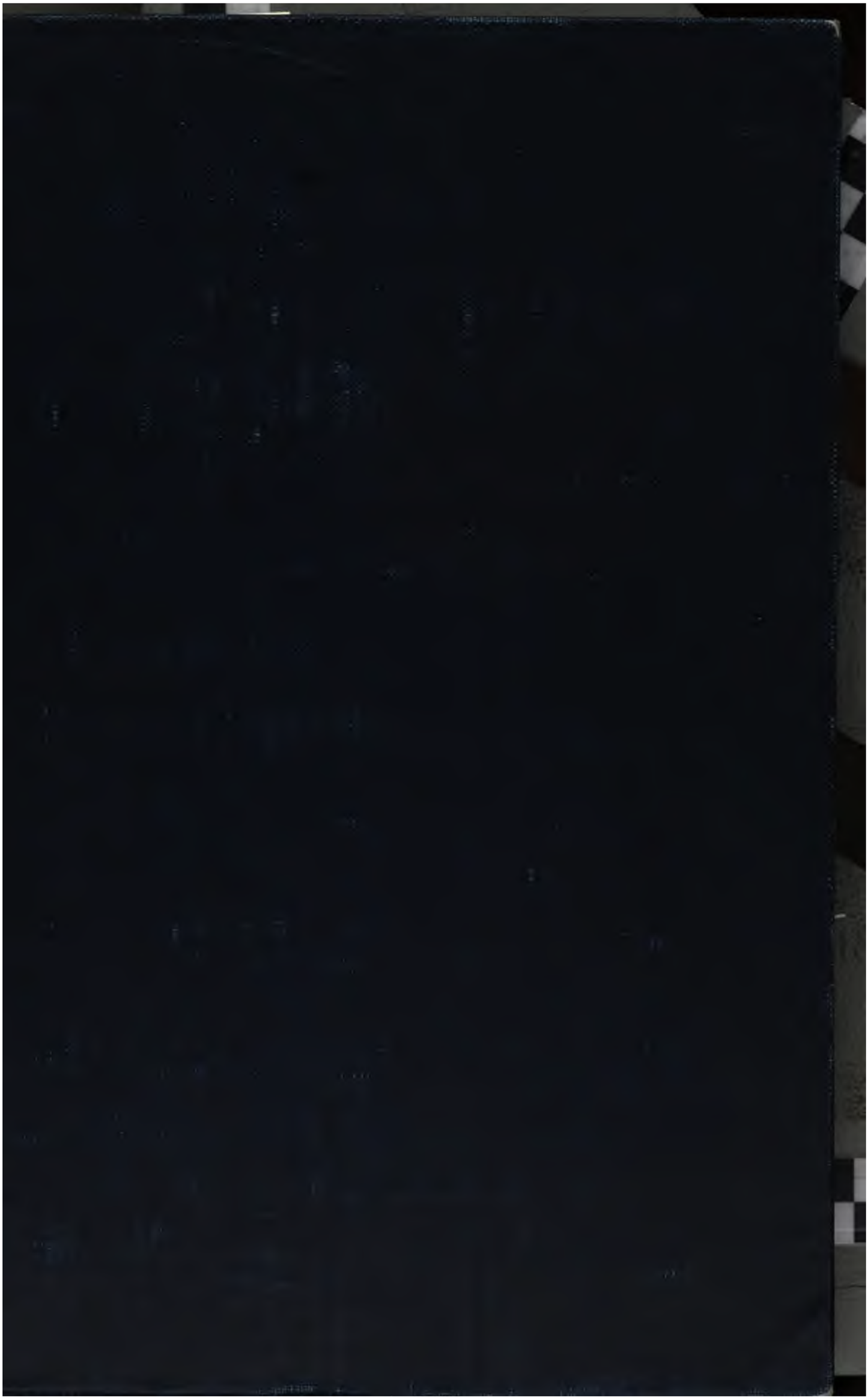

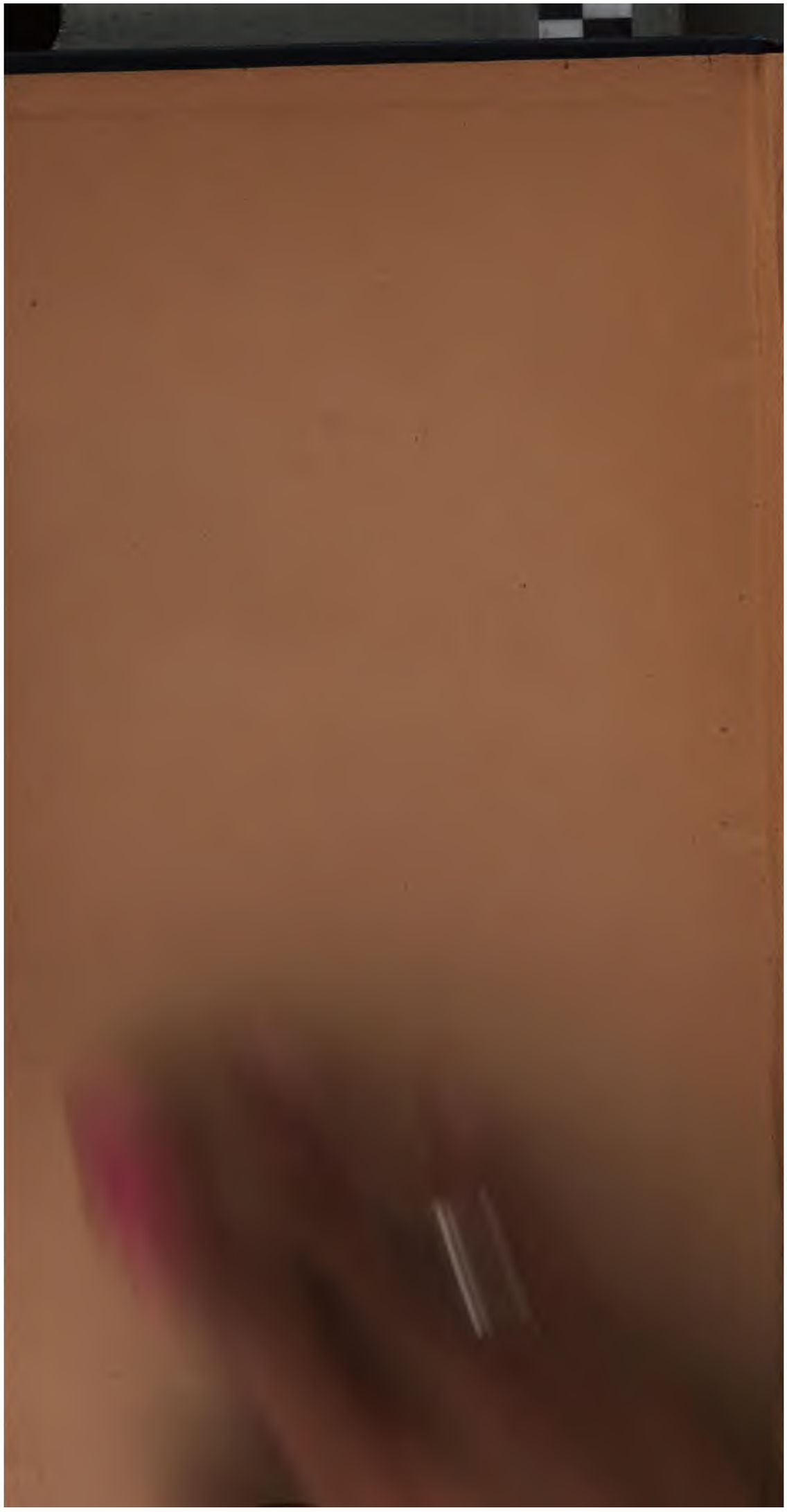

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MUSEUM OF PRACTICAL GEOLOGY.

FIRST REPORT

ON THE

COALS SUITED TO THE STEAM NAVY.

BY

SIR HENRY DE LA BECHE & DR. LYON PLAYFAIR.

Presented to both Houses of Parliament by Command of Her Majesty.

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CAPTAIN HAMILTON, R.N., to the EARL of LINCOLN.

MY LORD, *Admiralty, June* 28, 1845.

I AM commanded by my Lords Commissioners of the Admiralty to send you herewith a copy of a letter from Mr. Hume, M.P., with an American Report on the comparative usefulness of English and American coal, &c., and to suggest that you should call on Sir Henry De la Beche, Director General of the Geological Survey of the United Kingdom, to state whether he could undertake the investigation proposed by Mr. Hume, or what course he would recommend to be adopted for conducting the inquiry with the greatest effect.

I am, &c.,
(Signed) W. B. HAMILTON.

To the RIGHT HON. the LORDS of the ADMIRALTY.

MY LORDS, *Bryanstone Square, June* 10, 1845.

WHEN a reward was voted to Mr. Grant, for his patent rights to an artificial fuel, I had a strong desire to oppose the vote, as I was then anxious that the Admiralty should have ordered an inquiry into the several kinds of fuel that might be used for steam engines, with the view of ascertaining what fuels have the greatest evaporating power in the smallest space and weight.

I am informed that no inquiry of that nature has been instituted by any department of the Government, and therefore beg to recommend the subject as one deserving the immediate and serious attention of your Lordships.

The efficiency of the steamers must depend on the quality of the coals and fuel used for the Naval service, and without an accurate knowledge of the power of the coals to be used, the country may be paying the highest prices for an inferior article, and, depending on the power of the fuel, the public service may suffer disappointment at a moment when the greatest interests of the country may be at stake.

In whatever manner the supply of fuel for marine steamers is received, the importance of the inquiry I venture to recommend must become manifest to your Lordships, and I hope, therefore, the subject may receive attention.

The late Mr. A. P. Upham, of the United States, was strongly impressed with the importance of determining the nature and qualities of the several coals in the United States, with a view to their use in the steam navy of that country; and in 1842-3, directed a course of experiments to be made on the different kinds of coals of the United States, for the purpose of ascertaining their evaporative powers.

I have only this day received from the United States the report of that inquiry, and I have the satisfaction of sending a copy of that report to your Lordships, that you may see the result of that inquiry. They have decided by direct and practical tests the comparative usefulness of American and of English coals, as well as the relative value of the former in their numerous varieties; and I submit to your Lordships that a similar inquiry should be instituted into the comparative usefulness of the several kinds of English, Scotch, and Irish coals, with the view of ascertaining the best for the naval steamers of this country.

I may be allowed to point out to your Lordships that there is a public establishment in Craig's Court perfectly qualified to apply the requisite direct and positive tests to the coals without delay, and to that establishment may be added one chemist of eminence to assist in what is an object of great national importance.

I have, &c.,
(Signed) JOSEPH HUME.

SIR, *Office of Woods, June* 30, 1845.

WITH reference to the letter, of which a copy is enclosed from the Secretary of the Board of Admiralty, suggesting on the part of that board that an inquiry should be instituted into the comparative usefulness of British coal, I have to request that you will inform me whether, in the Laboratory of the Museum of Economic Geology, means are at present available for conducting this investigation, and if so, what is the course you would recommend for making it effective for the purposes to which such an inquiry would be obviously directed.

I am, &c.,
(Signed) LINCOLN.

To Sir Henry De la Beche,
&c. &c. &c.

Museum of Practical Geology,
MY LORD, *June* 30, 1845.

I HAVE the honour to state, in reply to your Lordship's letter of this day's date, respecting an inquiry into the comparative value of British coals for steam purposes, one so important to the Navy of this country, that the Laboratory of this establishment is available for conducting this investigation, with a moderate addition to its present means, at the same time that the extensive researches of the Geological Survey of the United Kingdom may also be made available for the same object.

By combining the services of the Museum and of the Survey, I apprehend that a mass of very valuable information on this head may be collected at comparatively moderate cost.

As the funds of the Museum of Economic Geology are, unaided, inadequate to an investigation of this order, I would suggest that the Admiralty be requested to furnish aid to the amount of 600*l.* for the remainder of the year ending the 31st March, 1846.

With this aid I have little doubt that we should be enabled to accomplish much this year which may be of value, and have organized a system of inquiry alike effective, and, viewing its national importance, which can be carried out at comparatively small cost to the public.

I have &c.,
(Signed) H. T. DE LA BECHE.

The Right Hon. the Earl of Lincoln.

MEMORANDUM.

The Admiralty having acceded to the recommendation made in the foregoing letter, and subsequently also supplied additional funds for the investigation; the latter was commenced as soon as the needful apparatus was erected and proper assistance procured, which could not be accomplished until March, 1846.

FIRST REPORT.

TO THE RIGHT HON. VISCOUNT MORPETH.

Museum of Practical Geology,
January 5, 1848.

My Lord,

We have the honour to transmit a First Report on the experiments which, under the sanction of the Earl of Lincoln, your Lordship's predecessor, we were requested by the Lords Commissioners of the Admiralty to superintend, respecting the value of different varieties of British coals, for the purposes of our naval service; and, according to your Lordship's instructions, we have forwarded a copy of this Report to the Admiralty, as the expenses of the investigation were incurred by that establishment.

The utility of such investigations having been fully recognized, both as regards questions of the greatest importance connected with our steam navy and as bearing on various branches of our national industry, in which the right use of our fossil fuel is so requisite, it is unnecessary to dwell on the practical application of the inquiry.

We would, however, observe, that experiments necessary to ascertain the true practical value of coal involve a very large series of observations, extended over a considerable period, and directed to special objects of inquiry. The qualities for which particular kinds of fuel are pre-eminent being so varied, it is impossible to deduce general results from a limited series of observations. Even in the one economical application of coals, their evaporative value, or their power of forming steam, one variety of coal which may be admirably adapted from its quick action for raising steam in a short period, may be far exceeded by another variety, inferior in this respect, but capable of converting a much larger quantity of water into steam, and therefore more valuable in the production of force. A coal uniting these two qualities in a high degree might still be useless for naval purposes, on account of its mechanical structure. If the cohesion of its particles be small, the effect of transport or the attrition of one coal against another by the motion of a vessel might so far pulverize it as materially to reduce its value. Even supposing the three qualities united, rapidity and duration of action with considerable resistance to breakage, there are many other properties which should receive attention in the selection of a fuel without the combination of which it might be valueless for our steam navy.

There is an important difference existing between varieties of coals in the bulk or space occupied by a certain weight. For the purposes of stowage-room this cannot be ascertained by specific gravity alone, because the mechanical formation of the fragments of coal may enable one of less density to take up a smaller space than that occupied by another of a higher gravity. This is far from an imaginary difference, being sometimes as great as 60 per cent., and not unfrequently 40 per cent. The mere theoretical determination of the density of coals would, therefore, give results useless for practice. The space occupied between two varieties of coals, often equally good as regards their evaporative value, differs occasionally 20 per cent., that is, where 80 tons of one coal could be stowed, 100 tons of another of equal evaporative value might be placed, by selecting it with attention to its mechanical structure. These facts are mentioned merely to show that a hasty generalization should not be made, and to account for our drawing attention to these various points as a means of preventing the selection of a fuel from any one quality. We do not, in the present state of this inquiry, consider it proper to offer any recommendation of our own as to particular kinds of fuel, leaving the experimental facts to decide for themselves.

After preliminary experiments had proved that no practical result could be attained by mere laboratory research, it was determined to test each variety of coal on a scale of sufficient magnitude to check the theoretical views by the practical results. As it was impossible for either of us to devote our whole time to this inquiry, our services being required by other official duties, we appointed assistants to superintend its special parts, under our general direction. On the selection of

assistants we have reason to congratulate ourselves, their duties having been conducted with great care and skill. To Mr. Wilson, since appointed Principal of the Royal Agricultural College of Cirencester, whose practical knowledge well fitted him for the task, the superintendence of the economical part of the experiments was first confided. To him and Mr. Phillips is due the erection of the boilers, and the experiments, to illustrate the practical evaporative power of the coals. After Mr. Wilson had for some time proceeded with the investigation, he was joined by Mr. Kingsbury, who volunteered his services to this department. The latter gentleman was formerly a distinguished student at the College for Civil Engineers, Putney, and from his engineering skill has rendered an especial service to this inquiry.

On the translation of Mr. Wilson to Cirencester, the practical superintendence of the investigation was intrusted to Mr. J. Arthur Phillips, a pupil of the École des Mines of Paris. The information obtained had pointed out improvements and corrections in the processes used, to which Mr. Phillips applied himself with much skill and success.

The corrections and the results of his experiments will be found in his appended Report. The excellent scientific education of Mr. Phillips, and his practical resources, rendered his services of great value.

The analyses of coals were intrusted to Mr. Wrightson (a pupil of Liebig), who had fitted himself by special study for an undertaking requiring so much delicacy of manipulation. Mr. Galloway, an assistant at the Museum of Practical Geology, gave his occasional services in analyzing gases and ashes from the furnaces, but he was not wholly retained for this purpose.

Mr. How, a very careful experimentalist, and assistant at the laboratory of the College for Civil Engineers, was appointed analyst after the retirement of Messrs. Wrightson and Galloway.

It is proper to mention, in terms of approbation, the services of the intelligent working engineer, William Hutchinson, whose assiduity soon enabled him to be of more important service than was to have been expected from his position.

The results obtained by the assistants, with accounts of the modes pursued, are appended, in order that the methods may be examined, and that special attention may be devoted to any particular department of the inquiry.

In the first section of the Appendix, a full description is given of the processes adopted in conducting the practical part of the experiments, as also plans and sections of the boiler, furnace, and apparatus employed.

The second section contains details of the observations and experiments made to ascertain the evaporative power of the different varieties of coals.

The third section describes the formulæ used for calculating the experiments, and for correcting and reducing them to one standard.

The fourth section contains the chemical experiments, including the ultimate and proximate analyses of the coals, and the determination of their calorific values.

It is unnecessary to repeat here the mode in which the experiments were instituted, as these are detailed in the first section of the Appendix, so that it will suffice to draw attention to the points observed in reducing and calculating the results. It will be obvious that there are several circumstances which must receive attention before the true evaporative value of a fuel can be obtained. Thus, the water in the tanks has a varying temperature during the day, dependent on atmospheric changes, and is always different from that in the boiler. The temperature of water in the boiler also varies with the external temperature, and the circumstances under which the experiments are made. The shape of a Cornish boiler favours an inequality in the temperature of the water in its various parts, the colder and denser water sinking to the bottom, and having a tendency to remain there, so that the temperature of water at the surface is far from being the mean temperature of water in the boiler, the difference between the surface and bottom water being, on an average, 70°. Other circumstances naturally affect the evaporative powers of the coal, as for example the fact that all the water exposed to the action of the fire in the boiler is not converted into steam, and that wood is used to light the fire. Another circumstance of considerable importance, is the expansion or contraction of the boiler from an increase or diminution of the temperature. In the early stage of the experiments, those conducted by Messrs. Wilson and Kingsbury, it was thought unnecessary to make a correction for this variation in conditions; but on ascertaining experimentally that the difference was as much as 69·625 lbs. of water in the contents of the boiler, between the temperature 150° and 212°, it

became desirable to make an allowance for it, even when the difference between the initial and final temperature was not greater than 10°. Other circumstances of less importance, but influencing the results, have been neglected, because the application of such corrections would have only complicated the results, and would have had little practical value when the errors of observation in such approximative experiments remain so large. Among these may be mentioned the quantity of gases evolved during combustion, the elevation in temperature of the air entering the fire-place, the barometrical and hygrometric conditions of the atmosphere, the radiation from the boiler (very small in amount, owing to its brick covering), the hygrometric state of the fuel, or the heat necessary for obtaining mechanical draught in the chimney. In most of these cases the necessary observations have been made, to enable the corrections to be applied, should it afterwards appear desirable.

In making the calculation for the evaporative value of a fuel, the quantity consumed was divided into two portions, the first being that necessary to raise the whole mass of water, exposed to the fire, from the *mean temperature* to 212°, the second portion being that required to evaporate the water taken from the tanks from a temperature of 212°. To enable this to be done, the mean temperature of the whole mass of the water is ascertained, that is, the temperature of the water in the boiler at its initial temperature after being mixed with the tank water at its average temperature. The average of the latter was the mean of several observations taken during the day, and is designated by t'.

Let w be the weight of water drawn from the tanks at temperature t'
W ,, in boiler ,, t'' this
being obtained from surface temperature corrected by experiment
t temperature after mixture.

Then $t = \dfrac{W\,t'' + w\,t'}{W + w}$.

The correction for the wood was made from data procured experimentally by Messrs. Wilson and Kingsbury, but it can only be employed for the particular wood used, as in subsequent experiments the evaporative value was found very different from another quality obtained. The coefficient of the evaporative power of the wood may be deduced from experiment, in which a certain weight of water was raised from a known temperature to the boiling point, and then a certain portion of it evaporated. The following formulæ have been used by Mr. Kingsbury for the calculation—

N is the total weight of wood used in raising (W + w) (the weight of water in the boiler, and of that let down from the tanks during the experiment) from the mean temperature t to 212°; then it is necessary to find the weight N′ necessary to evaporate w from 212°.

$$\text{Then } \frac{w}{N'} = e, \text{ the evaporating power.}$$

Let m be the weight of wood required to raise W + w from t to 212°, the number 1000 being assumed as the latent heat of steam.

N to evaporate W + w from 212°
N′ ,, w ,,

$$\text{Then } m + N' = N$$

$$\text{Now } \frac{l}{212 - t} = \frac{n}{m}$$

$$\text{But } \frac{n}{N'} = \frac{W + w}{w}$$

$$\therefore N' = n\,\frac{w}{W + w}$$

$$l\,(N - N') = (212 - t)\,n$$

$$= (212 - t)\,N'\left(\frac{W + w}{w}\right)$$

$$N\,l = N'\left\{\frac{W + w}{w}\,(212 - t) + l\right\}$$

$$= \frac{N'}{w}\left\{(212 - t)\,(W + w) + l\,w\right\}$$

$$\therefore \frac{w}{N'} = \frac{(212 - t)\,(W + w) + l\,w}{N\,l}$$

$$= e$$

or, introducing the value of t as given by the first formula,

$$\frac{(l + 212 - t)\, w + (212 - t'')\, W}{N\, l} = e$$

If q be the quantity of wood used in lighting the fire, $e\,q$ will be the weight of water evaporated from 212° by the wood, and must be deducted from the weight of water evaporated in calculating the work done by the coal.

The co-efficient of the evaporating power of the coals, or the number of lbs of water which one lb. of coal will evaporate from 212°, may be calculated as follows:—

Let P be the total quantity of coal consumed, then the work done by P will be to raise $W + w$ of water from t to 212°, and to evaporate $w - e\,q$ from 212°.

Let m be the weight of coal required to raise $W + w$ to 212° from t
p „ „ evaporate $w - e\,q$ from 212°
n „ „ „ $W + w$ from 212°

Then $\frac{w - e\,q}{p} = E$, the evaporating power.

Now $P = m + p$

$$\frac{212 - t}{l} = \frac{m}{n}$$

But $\frac{p}{n} = \frac{w - e\,q}{W + w}$

$$\therefore l\left(\frac{w - e\,q}{W + w}\right) = p\,\frac{212 - t}{P - p}$$

$$\frac{(W + w)\,(212 - t) + (w - e\,q)\,l}{P\,l} = \frac{w - e\,q}{p} = E$$

Introducing the values from which the mean temperature t was obtained (first formula), we have eventually

$$\frac{(l + 212 - t')\, w + (212 - t'')\, W - l\,e\,q}{P\,l} = E$$

in which W is the weight of water in the boiler;
w „ drawn from the tanks during the experiment;
t' the mean temperature of water in tanks;
t'' the corrected initial temperature of water in the boiler.*

In the preceding formulæ, the latent heat of steam has been taken at 1000°, the number generally used in this country; but after all the calculations had been made on this subject from the experiments by Messrs. Wilson and Kingsbury, and the results sent in to the Admiralty, Regnault's excellent memoir on the latent heat of steam was published. It became necessary, therefore, to use these new

* A small correction must be also made for the combustible matter in the *residua* of combustion, such as the soot and carbonaceous matter in the ashes; to do this with great accuracy, a series of observations and analyses would have been required, the labour and expense of which would not have been warranted by the amount of correction necessary. It was, therefore, considered sufficient to proceed as follows,—although the result is nothing more than a very rough approximation to the truth. For such an approximation it will be admitted that the evaporative value of the coal depends on the ratio of the combustible to the incombustible matter, and that this ratio confers a similar evaporative value on the quantity of ashes, cinders, and soot produced by the combustion; in other words, that if the combustible matter of the latter had been usefully applied in the production of steam, a similar effect would have been produced as if a corresponding quantity of coal had been burned. If then Q be the weight of coal containing the same quantity of combustible matter as the *residua* after its combustion in the furnace

$$\frac{(l + 212 - t')\, w + (212 - t'')\, W - l\,e\,q}{(P - Q)\, l} = E',$$ the corrected co-efficient of evaporating power.

Let then w_1 = weight of ashes after the experiment
w_2 = „ cinders „ „
w_3 = „ soot „ „

The weight of the cinders is taken after the clinkers are separated.

Let r_1, r_2, r_3 be the per centage of combustible matter in the ashes, cinders, and soot respectively;

Q the weight of coal containing the same weight of combustible matter;
r the per centage of combustible matter as found in the coal by analysis;

Then $r\,Q = r_1 W_1 + r_2 W_2 + r_3 w_3$

$$\therefore Q = \frac{r_1 W_1 + r_2 W_2 + r_3 w_3}{r}.$$

results in the future experiments. These, so far as they apply to the present inquiry, are reduced in the following table:—

TABLE No. I.—Showing the Specific and Latent Heat of Water and Steam.

Air Thermometer Centigrade.	Mercurial Centigrade.	Number of Unities of Heat abandoned by one kilo. of water in descending from T to 0°.	Air Thermometer Fahrenheit.	Mercurial Fahrenheit.	Number of Unities of Heat contained in one pound of water at T°.	Mean Specific Heat of Water between 0° and T cent. or between 32° and T Fahr.	Specific Heat of Water from T to T + d T.	Latent Heat of Steam saturated to the temperature T.	
								Centigrade.	Fahrenheit.
°	°		°	°					
0	..	0·000	32	..	32·000	..	1·0000	606·5	1091·7
10	..	10·002	50	..	50·003	1·0002	1·0005	599·5	1079·1
20	..	20·010	68	..	68·018	1·0005	1·0012	592·6	1066·7
30	..	30·026	86	..	86 046	1·0009	1·0020	585·7	1054·2
40	..	40·051	104	..	104·091	1·0013	1·0030	578·7	1041·6
50	50·2	50·087	122	122·36	122·156	1·0017	1·0042	571·6	1028·9
60	..	60·137	140	..	140·246	1·0023	1·0056	564·7	1016·4
70	..	70·210	158	..	158·381	1·0030	1·0072	557·6	1003·7
80	..	80·282	176	..	176·507	1·0035	1·0089	550·6	991·1
90	..	90·381	194	..	194·685	1·0042	1·0109	543·5	978·3
100	100·0	100·500	212	212·0	212·900	1·0050	1·0130	536·5	965·7
110	..	110·641	230	..	231·153	1·0058	1·0153	529·4	952·9
120	..	120·806	248	..	249·450	1·0067	1·0177	522·3	940·1
130	..	130·997	266	..	267·794	1·0076	1·0204	515·1	927·2
140	..	141·215	284	..	286·187	1·0087	1·0232	508·0	914·4
150	150·0	151·462	302	302·0	304·632	1·0097	1·0262	500·7	901·2
160	..	161·741	320	..	323·133	1·0109	1·0294	493·6	888·5
170	..	172·052	338	..	341·693	1·0121	1·0328	486·2	875·1
180	..	182·398	356	..	360·316	1·0133	1·0364	479·0	862·2
190	..	192·779	374	..	379·002	1·0146	1·0401	471·6	848·9
200	200·0	203·200	392	392·0	397·760	1·0160	1·0440	464·3	835·7
210	..	213·660	410	..	416·588	1·0174	1·0481	456·8	822·2
220	..	224·162	428	..	435·480	1·0189	1·0524	449·4	808·9
230	..	234·708	446	..	454·474	1·0204	1·0568	441·9	795·4

It also became desirable to introduce new corrections, which the progress of the inquiry showed to be needful. Thus, Mr. Phillips's careful experiments determined the alteration in the capacity of the boiler at different temperatures, and correction was in future made for this difference. The alteration in the capacity of the measuring tanks was also estimated, whenever the temperature differed 2° from that at which they were gauged. Another cause of error, for which allowance should be made, is any difference which may exist between the initial and final temperature at the beginning and close of the experiment. This difference being known by observation, the correction may be applied from the Table of Expansion of the Water in the Boiler, given in the Appendix. Introducing these new corrections into the experiments for ascertaining the coefficient of the heating power of the wood, the following are the formulæ used by Mr. Philips:—

$$\frac{(W + w - w')(l + t) + wt' + (w' - w)t''}{Pl} = E.$$

In which W is the water let down from the tanks during the experiment.

w = The weight of water (as found by the Table of Expansion) found in the boilers at commencement of experiment.

w' = The weight of water in boiler at close of experiment.

l = Coefficient of the latent heat of steam.

t = Quantity of heat necessary to raise the water in tanks from its mean temperature to that at which it is evaporated.

t' = Quantity of heat necessary to raise the water in the boiler from the initial to the final temperature.

t'' = Quantity of heat necessary to raise water at the temperature of tanks to the final temperature of water in the boiler.

P = Weight of combustibles consumed during experiment.

E = The coefficient of the heating powers of wood.

But when the initial is lower than the final temperature, the formula becomes—

$$\frac{(W + w - w')l + Wt + wt' + (w' - w)t''}{Pl} = E.$$

All the terms retaining their original value except the last, in which t'' is replaced

by t''' (or the heat necessary to raise the final temperature to that at which the water was expanded), and must be regarded as having a negative value, while t' becomes positive. If now q is the weight of wood used in lighting the fire, the formulæ for estimating the evaporative power of the coal will be

$$\frac{(W - E\,q + w - w')\,l + (W + w - w')\,t + wt' + (w' - w)\,t''}{P\,l} = E'$$

And

$$\frac{(W - E\,q + w - w')\,t + Wt + wt' + (w' - w)\,t'''}{P\,l} = E'.$$

As the experiments are strictly comparative, and under like conditions, the want of the other corrections, to which we have alluded above, will not be felt in examining the results; while their execution would have introduced a refinement into the experiments which never could be obtained in practice, and which, in fact, would be useless and unwarrantable, while, as previously remarked, the errors of observation in all such approximative experiments remain so large.

The only omitted correction which in appearance might be supposed necessary for practical purposes, is that for the hygroscopic condition of the fuel. Had wood been employed, this must have been done; but the hygroscopic nature of coal is very much less than that of wood. The latter contains ¼ of its own weight of hygroscopic water; and the heat necessary for the evaporation of this quantity might be shown by a simple calculation to be nearly equal to 22 per cent. of the total heat obtained by the combustion of the wood. The hygroscopic water in coal is however very small, as will be seen by the following determinations of some of the Welsh specimens experimented upon:—

	Hygroscopic water.
Graigola Coal	1·06 per cent.
Anthracite	2·44 „
Old Castle	0·74 „
Ward's Fiery Vein . . .	1·27 „
Myndd Newydd	0·67 „
Pentrepoth	0·78 „
Pentrefelin	0·70 „

Had we introduced corrections for these small quantities, practice would have been misled; because the coals will rarely reach a vessel in the dry state that they did in the present case, when they were packed in hogsheads and kept under cover.

It was found unnecessary to correct for any inflammable gases flying up the chimney, because repeated analyses of the chimney gases proved them not to contain any combustible constituent; the only products ever found being carbonic acid, sulphurous acid, oxygen, and nitrogen. The quantity of free oxygen in the chimney varied from ¼ to ½ of the oxygen, which combined with the fuel; in other words, nearly twice the quantity of air passses through the fire than that which is strictly necessary by theory.

With regard to the selection of the coals for trial, we have to refer to Mr. Wilson's letter inserted in the Appendix. This letter gives the information obtained in a tour made by Professor Wilson for the purpose of ascertaining the best coals fitted for trial in the South Wales coal district, and the ports from which they can conveniently be shipped. This district was selected because the varying character of the coals, from the bituminous to the anthracitic, offered those which were most likely to combine the qualities desired for naval purposes. It was intended, as being most convenient for the inquiry, to have adhered strictly to districts. In the experiments this has hitherto been done, except in special cases, at the request of the Admiralty.

The following Table (Table II., page 11) contains an abstract of the results, so far as regards the evaporative value of the fuel; the special characters of each of the coals being described in the experiments detailed in the Appendix.

This Table relates only to the economical value of the coals examined, and to the steam generated by a unit of the respective coals, without however implying a unit of time. The details with reference to time, which forms a most important element in the value of the respective fuels, will be found in Section II.

The economical results obtained by evaporation in the best applied practice are ascertained to be only a small part of the theoretical result following from the actual quantity of heat capable of being generated. Still, as a comparative statement, it is

TABLE II.—Showing the Economic Values of the Coals.

	Names of Coals employed in the Experiments.	Economic evaporating power, or number of pounds of Water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for fuel. — Lbs.	Weight of 1 cubic foot as calculated from the density. — Lbs.	Ratio of B. to C., or of the economical to the theoretical weight.	Difference per cent. between theoretical and economical weights.	Space occupied by 1 ton in cubic feet (economic weight).	Results of experiments on cohesive power of Coals per centage of large Coals.	Evaporating power of the Coal after deducting for the combustible matter in the residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal.	Rate evapo tion, numbe lbs. Wat evapor per h — Mea
		A.	B.	C.	D.	E.	F.	G.	H.	I.	
Welsh Coals.	Graigola	9·35	60·166	81·107	·742	34·8	37·23	49·3	9·66	581·20	441·
	Anthracite, Jones and Co.	9·46	58·25	85·786	·679	47·26	38·45	68·5	9·7	565·02	409·
	Old Castle Fiery Vein	8·94	50·916	80·42	·633	57·946	43·99	57·7	..	455·18	464·
	Ward's Fiery Vein	9.40	57·433	83·85	·685	46·	39·	46·5	10·6	608·78	529·
	Binea	9·94	57·08	81·357	·702	42·53	39·24	51·2	10·3	587·92	486·
	Llangennech	8·86	56·93	81·85	·695	43·76	39·34	53·5	9·2	523·75	373·
	Pentrepoth	8·72	57·72	81.73	·705	40·17	38·80	46·5	8·98	518·32	381·
	Pentrefelin	6·36	66·166	84·726	·781	28·051	33·85	52·7	7·4	489·62	247·
	Duffryn	10·14	53·22	82·72	·643	55·43	42·09	56·2	11·80	540·12	409·
	Mynydd Newydd	9·52	56·33	81·73	·689	45·09	39·76	53·7	10·59	536·26	470·
	Three-quarter Rock Vein	8·84	56·388	83·60	·674	48·26	39·72	52·7	..	498·46	486·
	Cwm Frood Rock Vein	8·70	55·277	78·299	·706	41·648	40·52	72·5	9·35	480·90	379·
	Cwm Nanty-gros	8·42	56·0	79·859	·701	42·60	40·00	55·7	8·82	471·52	404·
	Resolven	9·53	58·66	82·354	·712	40·39	38·19	35·0	10·44	559·02	390·
	Pontypool	7·47	55·7	82·35	·676	47·845	40·216	57·5	8·04	416·07	250·
	Bedwas	9·79	50·5	82·6	·611	63·565	44·32	54·0	9·99	494·39	476·
	Ebbw Vale	10·21	53·3	78·81	·676	45·98	42·26	45·0	10·64	544·19	460·
	Porth-mawr	7·53	53·3	86·722	·614	62·7	42·02	62·0	7·75	401·34	347·
	Coleshill	8·0	53·0	80·483	·658	51·85	42·26	62·	8·34	424·0	406
Scotch Coals.	Dalkeith Jewel Seam	7·08	49·8	79·672	·625	59·984	44·98	85·7	7·10	352·58	355·
	,, Coronation Seam	7.71	51·66	78·611	·657	52·17	43·36	88·2	7·86	398·29	370·
	Wallsend Elgin	8·46	54·6	78·611	·694	43·78	41·02	64·	8·67	460·82	435·
	Fordel Splint	7·56	55·0	78·611	·699	42·92	40·72	63·	7·69	415·80	464·
	Grangemouth	7·40	54·25	80·48	·674	48·35	40·13	69·7	7·91	401·45	380·
English Coals.	Broomhill	7·3	52·5	77·988	·673	48·55	42·67	65·7	7·66	383·25	397·
	Lydney (Forest of Dean)	8·52	54·444	80·046	·68	47·02	41·14	55·0	8·98	463·86	487·
	Slievardagh Irish Anthracite	9·85	62.8	99·57	·630	58·55	35·66	74·	10·49	618·58	473·
Patent Coals.	Wylam's Patent Fuel	8·92	65·08	68·629	·948	5·45	34·41	..	9·74	580·51	418·
	Bell's ,,	8·53	65·3	71·124	·918	8·91	34·30	..	8·65	557·0	549·
	Warlich's ,,	10·36	69·05	72·248	·955	4·49	32·44	..	10·60	715·35	457·

necessary to contrast the economical heat given out by a coal with the theoretical quantity. The cause of the difference between the applied and theoretical quantities is, at least in a great degree, obvious, and does not by the apparent difference prove the fallacy of calculation. Before the comparison can be made, it is necessary to have a knowledge of the composition of the respective coals, of this we subjoin a Table reduced from Section IV. (See page 12.)

Chemists differ as to the mode of calculating the theoretical heating values of coals, but, as an approximative rule, without insisting on its absolute accuracy, their calorific values are found to stand in relation to the quantity of oxygen required for their complete combustion. This may be estimated experimentally by heating the coal with an excess of litharge in the manner, and with the precautions described by Mr. Phillips in page 63, or it may be determined by calculation from the known equivalents of the combustible ingredients of the coal. From the quantity of lead reduced by the coal, the oxygen employed in its combustion may be estimated, and the calorific values stand in direct relation to this quantity. The amount of oxygen necessary to consume the combustible constituents may more accurately be determined by elementary analysis; and thus calculated, the results are generally found to be about ⅛ greater than those indicated by experiment with the litharge. The calculation from the elementary analysis depends upon the circumstance, that 6 parts, or one equivalent, of carbon requires 16 parts, or two equivalents, of oxygen for combustion, while 1 part of hydrogen requires 8 parts of oxygen; it is only necessary, therefore, to subtract from the hydrogen a quantity corresponding to the oxygen contained in the coal to enable the calculation to be made on these principles.

As the calorific values are only relative, it is useful to refer them to the

TABLE III.—Showing the Mean Composition of average samples of the Coals.

	Locality or name of Coal.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Per centage of Coke left by each Coal.
Welsh Coals.	Graigola	1·30	84·87	3·84	0·41	0.45	7·19	3·24	85·5
	Anthracite	1·375	91·44	3·46	0·21	0·79	2·58	1·52	92·9
	Oldcastle Fiery Vein	1·289	87·68	4·89	1.31	0·09	3·39	2·64	79·8
	Ward's Fiery Vein	1·344	87·87	3·93	2·02	0·83	Included in ash.	7·04	..
	Binea Coal	1·304	88·66	4·63	1·43	0·33	1·03	3·96	88·10
	Llangennech	1·312	85·46	4·20	1·07	0·29	2·44	6·54	83·69
	Pentrepoth	1·31	88·72	4·50	0·18	..	3·24	3·36	82·5
	Pentrefelin	1·358	85·52	3·72	Trace	0·12	4·55	6·09	85·0
	Duffryn	1·326	88·26	4·66	1·45	1·77	0·60	3·26	84·3
	Mynydd Newydd	1·31	84·71	5·76	1·56	1·21	3·52	3·24	74·8
	Three-quarter Rock Vein	1·34	75·15	4·93	1·07	2·85	5·04	10·96	62·5
	Cwm Frood Rock Vein	1·255	82·25	5·84	1·11	1·22	3.58	6·00	68·8
	Cwm Nanty-gros	1·28	78·36	5.59	1·86	3 01	5·58	5·60	65·6
	Resolven	1·32	79·33	4·75	1·38	5·07	Included in ash.	9·41	83·9
	Ponty Pool	1·32	80·70	5·66	1·35	2·39	4·38	5·52	64·8
	Bedwas	1·32	80·61	6·01	1·44	3·50	1·50	6·94	71·7
	Ebbw Vale	1·275	89·78	5·15	2·16	1·02	0·39	1·50	77·5
	Porthmawr Rock Vein	1·39	74·70	4·79	1·28	0·91	3·60	14·72	63·1
	Coleshill	1·29	73·84	5·14	1·47	2·34	8·29	8·92	56·0
Scotch Coals.	Dalkeith Jewel Seam	1·277	74·55	5·14	0·10	0·33	15·51	4·37	49·8
	Dalkeith Coronation Seam	1·316	76·94	5·2[illegible]	Trace.	0·38	14·37	3·10	53·5
	Wallsend Elgin	1·20	76·09	5·22	1.41	1·53	5·05	10·70	58·45
	Fordel Splint	1·25	79·58	5·50	1·13	1·46	8·33	4·00	52·03
	Grangemouth	1·29	79·85	5·28	1·35	1·42	8·58	3·52	56·6
English Coals.	Broomhill	1.25	81·70	6·17	1·84	2·85	4·37	3·07	59·2
	Park End, Lydney	1·283	73·52	5·69	2·04	2·27	6·48	10·00	57·8
	Slievardagh (Irish)	1·59	80·03	2·30	0·23	6·76	Included in ash.	10·80	90·1
Foreign Coals.	Formosa Island	1·24	78·26	5·70	0·64	0·49	10·95	3·96	..
	Borneo (Labuan kind)	1·28	64·52	4·74	0·80	1·45	20·75	7·74	..
	,, 3 feet seam	1·37	54·31	5·03	0·98	1·14	24·22	14·32	..
	,, 11 feet seam	1·21	70·33	5·41	0·67	1.17	19·19	3·23	..
Patent Fuel.	Wylam's Patent Fuel	1·10	79·91	5·69	1·68	1·25	6·63	4·84	65·8
	Bell's ,, ,,	1·14	87·88	5·22	0·81	0·71	0·42	4·96	71·7
	Warlich ,, ,,	1·15	90·02	5·56	Trace.	1·62	Included in ash.	2·91	85·1

heating power of pure carbon, 1 part of which requires 2·666 parts of oxygen for combustion, and is capable, according to Despretz, of heating 78·15 parts of water from its freezing to its boiling point. The calculation may be simplified by multiplying each part of lead obtained by 2·265, which gives at once the weight of water capable of being heated between these temperatures by a unit of the coal used in reducing the litharge. On these principles the following Table is constructed.—(*See* Table IV., page 13.)

With regard to the practical application of fuel, such a Table could not supersede experiment, as the economical values of the coal depend also on adventitious circumstances connected with their physical as well as their chemical condition. This Table, while on the whole it agrees with and confirms the practical results of experiments, still differs in a marked degree in one or two instances: this difference arising as much from the chemical as from the physical differences of the coals. Thus, if by destructive distillation, which occurs in furnaces before combustion, a large quantity of the constituents of the coal are rendered gaseous, so much heat is expended in this act that the heat developed by their after combustion is frequently not greater than that abstracted during their formation, in which case a thermo-neutrality occurs. To ascertain the proportion of fixed and volatile products in the various coals, the very difficult and elaborate process described in Section IV., page 55, was adopted; but the tediousness and chances of failure in this kind of analysis have only induced us to include a limited number of coals (those given in Table V.), especially as for steam purposes it was sufficient to determine the per centage of coke, as stated in Table II.

TABLE IV.—Showing the Calorific Values of the Coals.

	Name of Coal.	Quantity of Lead reduced by one part of Coal.	Oxygen removed from Litharge by one part Coal.	Quantity of Oxygen theoretically required by Carbon and Hydrogen.	Quantity of Oxygen required by Carbon alone.	Relative calorific Values, Carbon taken as 100, calculated from A. and B.	Number of lbs. of Water which 1 lb. of Coal can raise from 32° Fahr. to 212° Fahr., calculated from A.
		A.	B.	C.	D.	E.	F.
Welsh Coals.	Graigola	32·08	2·49	2·49	2·26	93·4	72·66
	Anthracite (Jones and Aubrey)	33·48	2·60	2·69	2·43	97·5	75·73
	Oldcastle Fiery Vein	31·42	2·44	2·71	2·34	91·5	71·16
	Ward's Fiery Vein	31·46	2·44	2·65	2·34	91·5	71·25
	Binea Coal	31·64	2·46	2·72	2·36	92·2	71·66
	Llangennock	32·66	2·53	2·59	2·28	94·9	73·97
	Pentrepoth	31·16	2·39	2·69	2·36	89·6	70·57
	Pentrefelin	30·52	2·37	2·53	2·28	89·2	69·13
	Powel's Duffryn	30·00	2·33	2·71	2·35	87·7	67·95
	Mynydd Newydd	30·34	2·35	2·67	2·25	88·5	68·72
	Three-quarter Rock Vein	26·62	2·06	2·34	2·00	77·2	60·29
	Cwm Frood Rock Vein	28·30	2·19	2·62	2·19	82·5	64·10
	Cwm Nanty-Gros	29·64	2·28	2·47	2·08	85·5	67·13
	Resolven	32·16	2·50	2·49	2·11	93·7	72·84
	Pontypool	27·46	2·13	2·55	2·15	80·2	62·19
	Bedwas	28·20	2·19	2·60	2·15	82·1	63·87
	Ebbw Vale	32·00	2·48	2·80	2·39	93·0	72·48
	Porthmawr Rock Vein	24·78	1·92	2·33	1·99	72·0	56·12
	Coleshill	26·14	2·03	2·28	1·96	76·1	59·21
Scotch Coals.	Dalkeith Jewel Seam	26·42	2·05	2·24	1·98	76·8	59·84
	,, Coronation Seam	24·56	1·96	2·32	2·05	73·5	55·63
	Elgin Wallsend	29·06	2·25	2·38	2·02	84·7	65·82
	Fordel Splint	29·00	2·25	2·47	2·12	84·7	65·68
	Grangemouth	28·48	2·20	2·46	2·13	82·8	64·51
	Broomhill (English)	25·32	1·96	2·63	2·18	73·5	57·35
	Slieveardagh (Irish)	30·10	2·33	2·31	2·13	87·7	70·44
Patent Fuels.	Wylam's Patent Fuel	28·82	2·23	2·52	2·13	84·0	65·27
	Bell's ,,	28·52	2·21	2·75	2·34	83·2	64·59
	Warlich's ,,	31·50	2·44	2·84	2·40	91·5	71·35

TABLE V.—Showing the Amount of Various Substances produced by the destructive Distillation of certain Coals.

	Name.	Coke.	Tar.	Water.	Ammonia.	Carbonic Acid.	Sulph. Hydrogen.	Olefiant Gas and Hydro-Carbon.	Other Gases inflammable.
Welsh Coals.	Graigola	85·5	1·2	3·1	0·17	2·79	Traces.	0·23	7·01
	Anthracite, from Jones, Aubrey and Co.	92·9	None.	2·87	0·20	0·06	0·04	?	3·93
	Old Castle Fiery Vein.	79·8	5·86	3·39	0·35	0·44	0·12	0·27	9·77
	Ward's Fiery Vein	..	1·80	3·01	0·24	1·80	0·21	0·21	..
	Binea	88·10	2·08	3·58	0·08	1·68	0·09	0·31	4·08
	Llangenneck	83·69	1·22	4·07	0·08	3·21	0·02	0·43	7·28

It has been for some time asserted, that the evaporative value of a bituminous coal is expressed by the evaporative value of its coke, the heat of combustion of its volatile products proving in practice little more than that necessary to volatilise them. If this supposition were even near the truth, the most useful practical results might follow from it. By a larger and better applied system of gas manufacture, the volatile products of distillation might be made useful not only for the purposes of illumination, but also for domestic heat, and the residual coke might be used with an equal economy in our manufactures*; thus preventing the emission of that smoke, which, at present, is so destructive to the comfort of our large cities. It is easy from analysis to examine whether the duty performed by the coal is to be attributed to its fixed ingredients or coke, by estimating the work which the latter is capable of performing. This may be

* In this case it would be necessary not to carry on the process of distillation so far as at present, as the residual coke would be more combustible and the gases purer.

done by subtracting the amount of ashes in the coal from its amount of coke (Table III.) and estimating the remainder as carbon. This carbon multiplied by its heating power, 13268, and divided by 965·7 or the latent heat of steam, indicates the number of pounds of water which the coke by itself could evaporate, without the aid of the combustible volatile ingredients of the coal. These results are placed in column B. of Table VI., in juxtaposition with the actual work done by the coal, and it will be seen, that notwithstanding several striking exceptions, which might have been expected, they on the whole show that the work capable of being performed by the coke alone, is actually greater than that obtained by experiments with the original coal.

The whole system of manufacturing coke is at present very imperfect. Besides losing the volatile combustible substances, which under new adjustments might be made of much value, an immense quantity of ammonia is lost by being thrown into the atmosphere. Ammonia and its salts are daily becoming more valuable to agriculture, and it is their comparative high price alone, which prevents their universal use to all kinds of cereal cultivation. By a construction of the most simple kind, the coke ovens now in use, might be made to economise much of the nitrogen which invariably escapes in the form of ammonia. As an inducement to this economy, we have appended to Table VI. two columns (H. and I.), showing the quantity of ammonia ($N H_3$), and its corresponding quantity of commercial sulphate ($N H_4 O, S O_3$), which each 100 lbs. of the respective coals may be made to produce. When it is remembered, that the price of sulphate of ammonia is about £13 per ton, or that 100 tons in coking is capable of producing, on an average, about 6 tons of this salt, its neglect is highly reprehensible.

By the preceding data, the actual value of the coals will be contrasted with that which is theoretically possible, supposing their combustion proceeded under circumstances which prevented any loss of heat. The actual duty obtained by a pound of coal from the boiler employed may be easily expressed by the number of pounds raised to the height of one foot. This result may readily be obtained by the simple formula—

$$W\eta \times 965{\cdot}7 \times 782 = x,$$

W representing water, of which η pounds are evaporated by a pound of coal. This formula is deduced from the fact that η pounds of water multiplied by 965·7,* or the coefficient for the latent heat of steam at 212°, indicates the number of pounds of water which would be raised 1° Fah.; and the number 782 arises from experiment on the mechanical force denoted by the elevation of a pound of water 1° Fah.; that force being equal to 782 lbs., raised to the height of one foot, according to the careful experiments of Mr. Joule, on the friction of oil, water, and mercury.

The theoretical value of the coals, with reference to the number of pounds of water which one pound of fuel will convert into steam, is obtained by the formula—

$$\left(\frac{C \times 13268}{965{\cdot}7}\right) + \left(\frac{H - h \times 62470}{965{\cdot}7}\right) = x$$

in which C is the quantity of carbon, H the quantity of hydrogen in a unit of fuel, and h the quantity of hydrogen corresponding to the oxygen contained in the coal. These multiplied by their heating powers, according to the results of Dulong, and divided by the latent heat of steam, indicate the number of pounds of water that can be converted into the latter by a pound of coal. The numbers thus obtained can be changed into the expression of mechanical force, by the previous formulæ.

The results of these calculations are thrown into Table VI.—(*See* page 15.)

The best Cornish engines are stated to raise 1,000,000 lbs. to the height of one foot, by every pound of coal consumed; so that only about $\frac{1}{8}$ of the *actual* force generated becomes available, or only $\frac{1}{11}$ or $\frac{1}{12}$ of the force theoretically possible, is applied in practice. The various experiments made on boilers, with regard to the evaporative power of coal, have not given very uniform results. Smeaton, in 1772, with one pound of Newcastle coal, evaporated 7·88 lbs. of water from 212°; Watt, in 1788, came to the conclusion that 8·62 lbs. of water might be evaporated by the same quantity of coal; and later (in 1840), Wicksteed found that 1 lb. of Merthyr coal could be made to evaporate 9·493 lbs. of water

* The coefficient for the latent heat of steam at 212° is generally taken at 1000°, but the above number is from the recent experiments of Regnault on this subject, as given in Table I.

TABLE VI.—Showing the Actual Duty, and that which is theoretically possible, of the Coals examined.

Name or Locality of Coal.	Actual number of lbs. of Water converted into Steam by 1 lb. of Coal. — Practical.	Number of lbs. of Water convertible into Steam by the Coke left by the Coal. — Theoretical.	Number of lbs. of Water convertible into Steam by the Carbon of the Coal. — Theoretical.	Number of lbs. of Water convertible into Steam by the Hydrogen of the Coal. — Theoretical.	Total number of lbs. of Water convertible into Steam by 1 lb. of Coal. — Theoretical.	Actual force generated, or the number of lbs. which 1 lb. of the Coal could raise to the height of 1 foot. — Calculated from heat obtained.	Force capable of being generated, or number of lbs. which could be raised to the height of 1 foot, by 1 lb. of Coal. — Theoretical.	Amount of Ammonia corresponding to the Nitrogen contained in Coal.	Amount of Sulphate of Ammonia corresponding to the Nitrogen contained in Coal.
	A.	B.	C.	D.	E.	F.	G.	H.	I.
raigola	9·35	11·301	11·660	1·903	13·563	7·060·908	10·242·471	0·497	1·932
nthracite {Jones, Aubrey, and Co}	9·46	12·554	12·563	2·030	14·593	7·143·978	11·020·303	0·225	0·990
ldcastle Fiery Vein .	8·94	10·601	12·046	2·890	14·936	6·751·285	11·279·329	1·590	6·175
'ard's Fiery Vein .	9·40	..	12·072	2·542	14·614	7·098·667	11·036·162	1·238	4·808
inea	9·94	11·560	12·181	2·912	15·093	7·506·463	11·397·892	1·586	6·741
angenock . . .	8·86	10·599	11·741	2·519	14·260	6·690·871	10·768·829	1·299	5·044
ntripoth . . .	8·72	10·873	12·189	2·649	14·838	6·585·146	11·205·322	0·218	0·848
ntrefellin . . .	6·36	10·841	11·749	2·038	13·787	4·802·928	10·411·630	Trace	..
well's Duffryn . .	10·149	11·134	12·126	2·966	15·092	7·664·295	11·397·137	1·76	6·835
ynydd Newydd . .	9·52	9·831	11·463	3·441	14·904	7·189·288	11·255·163	1·808	7·340
ree-quarter Rock Vein	8·84	7·081	10·325	2·781	13·106	6·675·768	9·897·355	1·299	5·044
wm Frood Rock Vein	8·70	8·628	11·300	3·488	14·788	6·570·043	11·167·563	1·347	5·232
vm Nanty Gros . .	8·42	8·243	10·767	3·165	13·932	6 358·593	10·521·131	1·919	7·448
esolven	9·53	10·234	10·899	3·072	13·971	7·196·840	10·550·583	1·675	6·505
ntypool	7·47	8·144	11·088	3·207	14·295	5·641·175	10·795·260	1·639	6·364
dwas	9·79	8·897	11·075	3·766	14·841	7·393·186	11·207·587	1·748	6·788
bw Vale . . .	10·21	10·441	12·335	3·300	15·635	7·710·361	11·025·198	2·622	10·182
rthmawr Rock Vein.	7·53	6·647	10·263	2·548	12·811	5·686·485	9·674·577	1·554	6·033
leshill	8·0	6·468	10·145	2·654	12·799	6·041·419	9·665·515	1·785	6·930
lkeith Jewel Seam .	7·08	6·239	10·242	2·071	12·313	5·346·655	9·298·499	1·214	0·471
lkeith Coronation .	7·71	6·924	10·570	2·202	12·772	5·822·417	9·645·125	Trace	..
allsend Elgin . .	8·46	6·560	10·454	2·968	13·422	6·388·800	10·135·991	1·712	6·647
rdel Splint . . .	7·56	6·560	10·933	2·884	13·817	5·709·141	10·434·286	1·372	5·327
angemouth . . .	7·40	7·292	10·970	2·722	13·692	5·588·312	10·339·888	1·639	6·364
oomhill	7·30	7·711	11·225	3·638	14·863	5·512·795	11·224·201	2·234	8·674
rk End, Lydney .	8·52	6·567	10·101	3·156	13·257	6·434·111	10·011·386	1·477	9·617
evardagh (Irish) .	9·85	10·895	10·995	1·487	12·482	7·438·497	9·426·124	0·279	1·084
rmosa Island . .	..	..	10·752	2·801	13·553	..	10·234·919	0·777	3·017
rneo (Labuan kind)	..	..	8·864	1·388	10·252	..	7·742·078	0·977	3·771
,, 3 feet seam .	..	..	7·461	1·295	8·756	..	6·612·333	1·132	4·620
,, 11 ,, .	..	..	9·652	1·948	11·600	..	8·760 057	0·813	3·158
ylam's Patent Fuel .	8·92	8·378	11·186	3·145	14·331	6·736·182	10·822·447	2·040	7·920
arlich's ,, .	10·36	11·292	12·368	3·596	15·964	7·823·637	12·055·652	Trace	..
ell's ,, .	8·53	9·168	12·074	3·343	15·417	6·441·663	11·642·569	0·983	3·818

from 80°, which is equal to 10·746 lbs. from 212°. In some experiments made on the boiler of the Loam's engine, at the United Mines, in Cornwall, each pound of coal was found, by a trial of six months, to evaporate 10·29 lbs. of water from 212°, this being the reduction of the result given, viz., that 234,210 cubic feet of water at 102° were evaporated by 700 tons of coal. Statements have indeed been made that 14 lbs. of water have been evaporated by 1 lb. of coal burned in Cornish boilers; but as this is the utmost quantity theoretically possible, it is difficult to conceive that it has been realized in practice, even in the best-constructed steam-engines.

To ascertain how far our boiler was inferior to Cornish boilers, as principally from its small size and less efficient coating it was likely to prove, we requested Mr. Phillips to make some experiments on one of the best engines in Cornwall, the results of which are given in the Appendix, Section II. It was found by these experiments, that 11·42 lbs. of water were evaporated by every pound of Welsh coal corresponding in composition to that of Mynydd Newydd; or, in other words, that improved Cornish boilers on a large scale may be assumed to have a superiority of nearly 20 per cent. over that used in these experiments. As the results stated in this Report are only relative, the comparison is not affected by this difference.

We have anxiously looked to the application of these experiments to the different varieties of patent fuel, but we have not been able to carry out our observations in this direction to the extent we could have desired, from our inability to procure patent fuels in sufficient number, although our applications to the patentees have

been numerous. Three varieties have been already examined, viz., those manufactured under the patents of Messrs. Wylam, Warlich, and Bell, and the results are given in the Tables. The varieties of patent fuel are generally made up in the shape of bricks, and are therefore well adapted for stowage; so that, though the specific gravity of patent fuels is lower than that of ordinary coals, from their shape and mechanical structure, there are very few coals which could be stowed in a smaller space per ton. While we look to the different varieties of patent fuel as of the highest importance, and, from their facility of stowage, as being peculiarly adapted for naval purposes, and perhaps even destined to supersede ordinary coal, at the same time, the greater part do not appear to be manufactured with a proper regard to the conditions required for war steamers. It is usual to mix bituminous or tarry matter with bituminous coal, and from this compound to make the fuel. An assimilation to the best steam coals would indicate, however, the very reverse process, and point to the mixture of a more anthracitic coal with the bituminous cement. As the greater part is at present made, it almost impossible to prevent the emission of dense opaque smoke, a circumstance extremely inconvenient to ships of war, as betraying their position at a distance at times when it is desirable to conceal it. Besides this and other inconveniences, the very bituminous varieties are not well suited to hot climates, and are as liable to spontaneous combustion as certain kinds of coal. To avoid these inconveniences, some kinds of patent fuels have been subjected to a sort of coking, and thus, in a great measure, obtain the desired conditions. There is little doubt, however, that notwithstanding the large number of patents in operation for the manufacture of fuel, its value for the purposes of war steamers might be much enhanced by its preparation being specially directed to this object. It will be seen, by reference to Table II., that the three patent fuels examined rank among the highest results obtained. Should it be desirable to continue this inquiry, we conceive that it would be advantageous to pay especial attention to this subject, by experimenting upon proper mixtures of different coals. Even anthracite may be introduced into such mixtures with advantage.

It is of much importance in an economical inquiry on coals, to obtain exact information as to the effects likely to be produced upon them by stowage, and continued exposure to high temperature, not only as regards their deterioration, but also as to the emission of dangerous gases by their progressive changes.

The retention of coal in iron bunkers, if these are likely to be influenced by moisture, and especially when by any accident wetted with sea-water, will cause a speedy corrosion of the iron, with a rapidity proportionate to its more or less efficient protection from corroding influences. This corrosion seems due to the action of carbon or coal forming with the iron a voltaic couple, and thus promoting oxidation. The action is similar to that of the tubercular concretions which appear on the inside of iron water-pipes, when a piece of carbon, not chemically combined with the metal, and in contact with saline waters, produces a speedy corrosion. Where the "make" of iron shows it to be liable to be thus corroded, a mechanical protection is generally found sufficient. This is sometimes given by Roman cement, by a lining of wood, or by a drying oil driven into the pores of the iron under great pressure.

Recent researches on the gases evolved from coal, prove that carbonic acid and nitrogen are constantly mixed with the inflammable portion, showing that the coal must still be uniting with the oxygen of the atmosphere, and entering into further decay.

Decay is merely a combustion proceeding without flame, and is always attended with the production of heat. The gas evolved during the progress of decay, in free air, consists principally of carbonic acid, a gas very injurious to animal life. It is well known that this change in coal proceeds more rapidly at an elevated temperature, and therefore is liable to take place in hot climates. Dryness is unfavourable to the change, while moisture causes it to proceed with rapidity. When sulphur or iron pyrites (a compound of sulphur and iron) is present in considerable quantity in a coal still changing under the action of the atmosphere, a second powerful heating cause is introduced, and both acting together, may produce what is termed *spontaneous combustion*. The latter cause is in itself sufficient, if there be an unusual proportion of sulphur or iron pyrites present.

The best method of prevention, in all such cases, is to ensure perfect dryness in the coals when they are stowed away, and to select a variety of fuel not liable to the progressive decomposition to which allusion has been made. This is, how-

ever, a subject of so much importance to the steam navy, that it continues to receive our careful attention; and, beyond these general recommendations, it would be premature to offer any decided course for adoption, from the present limited series of observations.

Several varieties of coal were transmitted from Formosa and from Borneo, for analysis, the results of which are contained in the accompanying table. The quantity of each kind was so small, that no experiments could be made on their evaporative value. We extract from the preceding table the following results:—

Name.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ashes.	Specific Gravity.
Formosa Island . . .	78·26	5·70	0·64	0·49	10·95	3·96	1·24
Borneo, Labuan kind . .	64·52	4·74	0·80	1·45	20·75	7·74	1·28
,, 3 feet seam . .	54·31	5·03	0·98	1·14	24·22	14·32	1·37
,, 11 feet seam . .	70·33	5·41	0·67	1·17	19·19	3·23	1·21

It may be desirable to sum up, in a few words, some of the principal points alluded to in the previous parts of this Report. It has been shown that the true practical value of coals for steam purposes depends upon a combination of qualities which could only be elicited by carefully and properly continued experiments. Their qualities, so far as regards steam-ships of war, may be stated as follows:—

1. The fuel should burn so that steam may be raised in a short period, if this be desired; in other words, it should be able to produce a quick action.
2. It should possess high evaporative power, that is, be capable of converting much water into steam, with a small consumption of coal.
3. It should not be bituminous, lest so much smoke be generated as to betray the position of ships of war when it is desirable that this should be concealed.
4. It should possess considerable cohesion of its particles, so that it may not be broken into too small fragments by the constant attrition which it may experience in the vessel.
5. It should combine a considerable density with such mechanical structure that it may easily be stowed away in small space; a condition which, in coals of equal evaporative values, often involves a difference of more than 20 per cent.
6. It should be free from any considerable quantity of sulphur, and should not progressively decay, both of which circumstances render it liable to spontaneous combustion.

It never happens that all these conditions are united in one coal. To take an instance, anthracite has very high evaporative power, but not being easily ignited, is not suited for quick action; it has great cohesion in its particles, and is not easily broken up by attrition, but it is not a caking coal, and therefore would not cohere in the furnace when the ship rolled in a gale of wind; it emits no smoke, but from the intensity of its combustion causes the iron of the bars and boilers to oxidate or waste away rapidly. Thus, then, with some pre-eminent advantages, it has disadvantages which, under ordinary circumstances, preclude its use. The conditions above alluded to may, however, often be united in fuels artificially prepared from coals possessing these various qualities, somewhat in the manner of what are usually termed "patent fuels," and we have recommended that experiments should be made with this object, especially directed to the wants of the Steam Navy. Whilst we look with this view to artificial fuel as being of special importance, it was quite necessary to obtain a knowledge of coals in different districts, and, for this purpose, Wales was first selected for examination, as producing coals of all kinds varying from bituminous to anthracitic.

While the experiments devised to obtain information on the various points alluded to have been conducted with all proper precaution, in order that constant *comparative* results might be procured, they have not been overburdened with scientific corrections, which might have been necessary to obtain absolute truth, but would have introduced an affectation of accuracy where practical results only were required; to the latter, therefore, this Report has been principally confined. The Report has been so divided as to bring the results together without complicating them with the details of the properties peculiar to each coal, information on which is of the highest value. Hence, in Table II., the practical results of the

experiments are brought together, while the equally practical information regarding each coal, its local position, the port from whence it is shipped, its price, its peculiar characteristics in burning, the greater or less quantity of smoke and of ashes which it produces, the description of the coal, its geological position, and other similar points of importance in practice, are detailed for each coal in Section II. of the Appendix.

The composition and specific gravities of the coals, and the quantity of coke which they produce, are given in Table III., not only as a means for their future identification, but also as a standard of quality, with relation to which particular kinds may be purchased. The amount of sulphur, as given in this table, is of considerable importance in determining the value of the coal for naval purposes, as a means of avoiding the risk of spontaneous combustion.

The heating values of the coal are given in Table IV., as a simpler and more ready method of identification, enabling the purchaser to insure the sample of the coal of a certain heating value.

Table V. shows how the inquiry might easily be extended to other branches of national industry, especially to gas manufactures, but is only adduced as an example of its applicability for such purposes.

Table VI. is principally for the purpose of showing that the actual duty obtained by the combustion of coal in the best applied practice is only a small part of that which the fuel is capable of producing, and is brought forward as an inducement to improvement in the construction of the furnaces and boilers employed for the production of steam. Attention is also drawn in this table to the great loss which agriculture suffers by the waste of ammonia always produced in the coking of coal, and which might to a great extent be economised by very simple adjustments to the ovens used in coking. The economy and consequent reduction of price in the ammoniacal salts, by preventing this great loss in a material so well fitted to aid increased production in land, would be a great boon to agriculture. Suggestions have also been thrown out as to the more economical application of fuel for domestic and for manufacturing purposes.

In concluding this First Report, we cannot refrain from drawing attention to the kind manner in which we have been assisted by various public and private institutions and companies, without whose aid the expenses of the inquiry would have been materially increased.

The College for Civil Engineers, at Putney, afforded us, gratuitously, ground upon which to erect the boilers, and a house and yard for the stowage of the coals. The laboratory and workshops of the college were also placed at the disposal of the investigation, and have constantly been used. The Principal of the College, the Rev. Mr. Cowie, on all occasions, afforded his valuable aid in the prosecution of the experiments.

The owners of the collieries, from which the coals were obtained, furnished them free of expense; and the Great Western Railway Company, with an enlightened liberality, carried those sent to Bristol on their railway to London without charge. To Mr. George Rennie, the eminent engineer, the inquiry is especially indebted. This gentleman not only lent a tubular boiler, gratuitously, to enable the experiments to be repeated on this kind of boiler, but he also offered his premises for the prosecution of the experiments, which offer was accepted, until the larger space at the College for Civil Engineers was placed at the disposal of the investigation.

Such ready and liberal co-operation of the public shows their appreciation of the important practical results which may be expected from these experiments. Seeing the present effective state of the boilers and other apparatus erected at Putney, consequently, that the expenditure on this account has been incurred, and that any further charges for continuing these investigations would chiefly consist of payments of salaries to the persons employed as assistants, we would suggest for consideration, that these experiments may be extended to the coals of other districts than those the coals from which have been examined, and that the needful expenditure may be sanctioned for one or two years more. Should this be deemed advisable, we should anticipate that a most important body of information would be accumulated, alike important to the naval service and the public at large.

We have the honour to be, &c.,

H. T. De La Beche.
Lyon Playfair.

APPENDIX.

Section I.—Description of Boiler and Apparatus, &c., by Professor Wilson, F.R.S.E., and Mr. J. Arthur Phillips.

Admiralty Coals Investigation.

Sir, *Cirencester, May* 21, 1847.

I now transmit to you the results of that portion of the Admiralty Coal Investigation which was committed to my charge, and which has reference to the comparative evaporating power of the different coals furnished for the service of these experiments.

In drawing up this report, I have had the valuable assistance of Mr. W. S. Kingsbury, who also afforded me the aid of his services during nearly the whole period that the trials were being made. We have described as distinctly as possible the nature of, and the method pursued in conducting, the experiments, the results of which have been calculated, and are presented in a tabular form at the end of part 2 of the report.

In an Appendix is given the formulæ employed in the calculations, as also the results of some observations and experiments made during the progress of the investigation.

We have not ventured to make any deduction of principles, either from the experiments themselves, or from the observations made during their progress, being satisfied that, although many points of great importance and interest have presented themselves, still, from the limited means at our disposal, and necessarily imperfect character of our observations, we should not be justified in drawing any definite conclusions in a matter which requires more extended observation, and which is affected by so many modifying circumstances.

I have, &c.,

Sir H. T. De la Beche, John Wilson.
&c. &c. &c.

General arrangement of Apparatus for testing the evaporating power of the Coals.

The boiler-house (marked A on the plan, plate No. 1), which was erected for the purpose of carrying out the experiments, is built with one end against the side of the building (B) employed as the laboratory and chemical lecture-room of the College for Civil Engineers, forming a rectangular building, 35 feet in length and 16 ft. 6 in. in breadth, covered with a "lean-to," or sloping roof, the height of the wall on the lowest side being about 12 feet above the floor line. A room (C), occupying the angle between a portion of the side of the boiler-house and the remaining part of the side of the laboratory, and communicating with both by means of doors, contains the barometer and other apparatus employed in the analysis of the gases, and formed a convenient place for the determination of the combustible matter in the residua, the density of the coals, and other purposes more strictly connected with the chemical part of the investigation.

The brickwork of the boiler is built against the end wall farthest removed from the laboratory, its width being 7 feet 8 inches, and length 15 feet; the side is separated from one side wall of the boiler-house by an interval of 18 inches, and from the other, consequently, by a space of 6 feet. This space of 18 inches prevents loss of heat from the boilers by conduction through the external wall, and furnishes ready means of access to the base of the chimney (D), which occupies the corner of the building at one extremity. A slate roof covers the building, the slates being laid on a substantial layer of asphalted felting, which serves the double purpose of preventing the communication of heat from the air in the building to the slates, and also down currents of cold air from outside, through the spaces round their edges.

On the other angle of the building, and at the distance of its width from the chimney, are placed the tanks (E, F) which supply the boiler with water.

They are made of wrought-iron plates riveted together, and are placed outside the roof on the wall, the cast-iron pipe (G), which supplies them with water, being brought up inside the building, in the angle of the wall, to defend it from the action of the frost. The extremity of the pipe is furnished with the means of directing the flow of water into either tank at pleasure, and a two-way cock, *b*, connected with the tanks, directs in a similar way the supply from them to the boiler. The cock *b'* on the feed-pipe, a short distance below this, regulates the quantity of water admitted to the boiler.

The boiler is cylindrical in form, 12 feet in length and 4 feet in diameter, having flat ends, with an internal flue 2 feet 6 inches in diameter, in which, at one end the grate is placed, forming the arrangement usually known by the name of the "Cornish boiler." The flues are on the plan known technically by the name of "split" or "bridle" draft, in which the column of heated air, after leaving the fire, passes through the internal flue to the rear end of the boiler, where it divides, returning along the outside of the boiler on both sides to the front, the two

branches, which are each 2 feet 6 inches deep, then turn down at right angles to their former course, and uniting under the boiler in the bottom flue, which is 2 feet 6 inches wide, traverse its whole length again, and finally enter the base of the chimney after exposing, during a course of about 36 feet, an area of 197·6 square feet of boiler surface to the heating action.

In the horizontal part of the flue at K, just before entering the chimney, a damper is placed, sliding vertically in a cast-iron frame, which is worked by means of a rod passing through a stuffing-box and attached to a cord, K′, carried over two pullies, and furnished with a balance-weight, so that a person standing near the fire-door can regulate the amount of draught with great convenience.

The chimney, its internal dimensions being 13½ inches by 13½, and consequently having a sectional area of 182¼ square inches, is carried up in brickwork, with a stone coping, to a height of 29 feet 6 inches above the base of the flue; a wrought-iron chimney-pot succeeds this, making the whole height 35 feet 6 inches.

Apertures were made in the chimney at D′ D″, about 6 feet from its base, for the purposes of making observations on the temperatures of the currents, and of obtaining samples of the gases for analysis. At the end of each of the side flues, and at the base of the chimney, openings were made through the external wall for the purpose of drawing out the soot at the end of each set of experiments. The floor of the flues is laid in fire-tiles to facilitate its removal, and the apertures at the end are closed and loss of heat prevented, when the furnace is in action, by means of stone doors 4 inches thick, then an interval for air, about 1 inch thick, and finally cast-iron hanging doors lined with fire-clay.

The fire-grate is 2 feet 6 inches wide and 2 feet long, thus giving an area of 5 square feet of grate surface; the bars are ¾ inch in thickness with ½ inch spaces between them. In the front end of the grate, near the fire-door, is an iron plate, for the purpose of gradually heating the bituminous and anthracite coals, which is 10 inches wide and slopes down to the grate, and behind this is another plate 8 inches wide, which slopes upwards to the fire-door, contracting in its width to 15 inches, which is the width of the aperture for the introduction of fuel.

The doors* used for closing the entrances to the grate and ash-pit are of a novel construction and are well adapted for preventing loss of heat, regulating the direct supply of air to the fire, and the convenient application of fuel.

The arrangement will be understood from the following description:—

c, *d*, is a large cast-iron plate let into the brick-work, and having four projecting brackets *ee*, *ff*, in which are secured the ends of stout cylindrical bars, which are to carry the doors. The apertures to the grate and ash-pit are surrounded with an iron rim, or edge, about ½ inch wide, the lower part being continued backward along the plate, forming a kind of guide, *g*, *h*. The fire-door, which exactly resembles the ash-pit door, consists of a rectangular cast-iron box, having its edge ground so as to fit accurately the iron rim before described, and the interior is filled with, first, a layer of fire-brick, then a space for air, and then another thickness of fire-brick, which effectually prevents loss of heat. The top of the door has projecting ledges, forming the cheeks for two friction-wheels, *l*, *l*, which run on the cylindrical bar already mentioned, so that, when the door is drawn sideways by means of the handle K at its back, the wheels roll along the bar, the lower part of the door sliding, at the same time, along the ledge closely or guide, *g*.

The two sides of the aperture are sloped gradually so as, with the lower edge, to project more at bottom than at the top; this causes the weight of the door to act in keeping the surfaces in contact.

There are three safety-valves (marked N on plan, plate 1), one of which is loaded, directly having an area of 5·4 square inches, and two smaller steelyard valves, each having an area of 2·07 square inches. In the experiments, the boiler was worked the first two days with a pressure of 1 lb. per square inch, and generally on the third day with a pressure of 3 lbs. on the inch.

The thickness of brickwork at the crown of the boiler is 4½ inches, and the walls were brought up on a level with it, and then covered with a paving of 3-inch York landing, thus forming a large platform, affording convenient access to the different thermometers and apparatus.

The brickwork was very carefully executed, being laid with hoop-iron bond, and every course well grouted so as to insure sound work, and entirely to prevent the passage of the external air into the flues. Openings were made into the side flues at H, I, in about the middle of their length, in which were fixed iron tubes, closed at the lower end, and containing oil, in which the thermometers were placed for giving the temperatures; a similar tube was inserted at K in the base of the chimney, and another in the boiler at L, to give the initial temperature of the water in it.

For drawing samples of the gases, the products of the combustion of the coals, a simple arrangement was adopted. A series of glass tubes, narrowed at each end, were connected together by caoutchouc tubes, and introduced into the iron tube of the chimney. The other end of the system of tubes was connected with a gas-holder filled with water. On opening the stop-cock of the gas-holder, connection was established between the chimney and the former, and a current of the chimney gases flowed through the tubes. After this had continued for some minutes, so as to expel the air, the caoutchouc joints were tied and the tubes removed. Their contracted parts were afterwards sealed by a blow-pipe's flame, and laid aside for analysis.

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* The fire doors were made under the direction of the patentee, Mr. Sylvester, who liberally remitted his patent right on the occasion of this investigation.

The method adopted for analysing the products of combustion belongs more particularly to the chemical part of the investigation, and will not, therefore, be described in this place.

The dew-point was taken at about the middle of each day's experiment, by means of a Daniell's dew-point hygrometer. The situation chosen for the observation was at the end of the boiler-house, farthest removed from the boiler, and the instrument was placed on a small wooden ledge, fixed against the wall at such a height as to bring the bulb of the instrument on a level with the observer's eye.

The two observations seldom gave a difference of 1°, in most cases much less.

Method of testing the cohesive power of the Coals.

For this purpose a wooden cylinder was employed 3 feet in diameter and about 4 feet long, each end having a bearing or gudgeon attached to it, on which the whole was made slowly to revolve. In the interior, three shelves tending to the axis were fixed, each being six inches in width: they were for the purpose of forming a lodgment for the coals, and of carrying them up towards the top of the cylinder during its revolution, thus insuring a certain amount of fall. An aperture was made at one end for the purpose of putting in the coals and for taking them out, which was closed, and rendered perfectly dust-tight by an oak door, firmly secured by an iron bar and staple. The cylinder was supported by a tressle at one end, the other gudgeon resting on a block let into the wall, and motion was communicated by a band passing round its circumference.

The coals to be tested were first broken to the size always employed in our experiments on their evaporating power, and then thrown on a sieve, the meshes of which were one inch square. Of the coals left on the sieve 100 lbs. were taken and put into the cylinder, which was then turned a certain number of times.

The whole was then allowed to rest a short time for the dust to settle, when the door was opened, and the coals again thrown on the same sieve, and the weight of coals remaining in it gave the per centage of large coals found in the tables.

The values given in the tables are the mean of two trials with each coal, with 50 revolutions.

The box in which the coals were weighed for supplying the fire, and also to obtain the economic weight, was 2 feet long, 2 feet wide, and 1 foot 6 inches deep, and consequently contained six cubic feet. The large coals were reduced to pieces, not exceeding 1 lb. weight previous to weighing, and this was the maximum size employed throughout the experiments.

Method of conducting the Experiments.

Having described the boiler and apparatus connected with it, we have now to state the course pursued in conducting the experiments.

Let us suppose the water in the boiler to be cold, and to stand about 1 inch below the normal level. The fire was lighted, and any coals that might be convenient employed to get up the steam in the afternoon of the day preceding the commencement of the experiments. As soon as this was the case, the fire was allowed to burn out, when the fire and ashpit doors, as well as the damper, were closed.

The next morning the first thing done was to open the safety valve, to equalize the external and internal pressures, and then sufficient water was let down from the tanks to raise that in the boiler to the normal level.

The depth of the water in the tanks was then guaged, and the first observation of its temperature made. The ashes, cinders, and soot were next cleared out, and after noting the temperature of the water in the boiler, the fire was lighted with a weighed portion of wood, and the exact time was then observed.

The coals were then gradually added till the fire was of the proper size and form. The form of fire was slightly varied according to the kind of coal employed, our object being to burn the coal to the best advantage, with as little smoke appearing at the chimney top as possible.

The observations of the temperatures of the two side and escape flues, and of the water in the tanks, then succeeded each other at regular intervals of about an hour each.

When the steam raised the safety-valve, the time was observed and entered under the heading "Steam up." The damper was adjusted as soon as the fire was sufficiently established, and was not disturbed during the day, except under peculiar circumstances.

When by evaporation the water had sunk about 1 inch below the normal level, the deficiency was supplied from the tanks above: this was the plan pursued at first, but latterly we found it more convenient to allow the water to flow in continuously so as to maintain the water in the boiler at a constant level, which was easily accomplished after a little experience.

In the management of the fire, care was taken to supply the coals in pieces not exceeding 1 lb. in weight, and in quantities of not more than one or two shovels-full at a time, spread evenly on the fire, except in the cases of the anthracite and some of the bituminous coals. In the case of the anthracite, it was found that the sudden application of heat caused the pieces to split, and fall through the bars, and hence a gradual heating on the dead plate was beneficial. With the bituminous coals a preparatory process of partial cooking on the dead plate prevented them from caking in the fire, which would have impeded the passage of air through the grate, besides giving better opportunity for burning the smoke and gases, by passing them over a large surface of ignited fuel.

The duration of the experiment was reckoned from the time the steam was up to about that of the last application of fuel, after which the fire was allowed gradually to burn out, when the damper, and furnace, and ashpit doors were closed.

During the day the ashes were thrown up in small quantities from time to time when the fire was burning clear and well.

The weight of coals consumed was then ascertained, by deducting the weight left from the gross weight provided for the day's trial, and the experiment terminated.

The next morning, when the level of the water in the boiler was adjusted by turning down a supply from the tanks, their depth was guaged, and the quantity evaporated the previous day was thus ascertained. The ashes and cinders were then removed, the clinkers if present separated, and the weight of each taken. The soot was cleared out at the end of the last day's experiment, and the total weight recorded, which divided by the number of trials gave the average weight.

Samples of the ashes, cinders, and soot were then put aside in bottles, for the purpose of ascertaining the per centage of combustible matter present in the residue.

The barometer was observed at about 11 o'clock in the day, being generally about two hours after the steam was up.

Method of estimating the quantity of Combustible Matter in the residue.

This consisted in heating the powdered substance in a stream of oxygen gas, by which the organic matter was dissipated chiefly as carbonic acid and water, and estimating the loss as combustible matter.

For this purpose a piece of German glass tube, 4 inches long and half an inch in diameter, was drawn out at one end to a small orifice, which was then loosely obstructed by a piece of asbestos. It was then weighed, and again after the introduction of a small quantity of the substance; after which it was attached to the cock of an ordinary gasholder filled with oxygen, by means of a piece of glass tube and a cork.

A lamp was next placed under the tube, and the powder in it gradually heated up to incipient redness; when this was the case, the cock was opened, and a slow current of oxygen was made to pass over the heated material. Combustion then commenced, and was continued till the organic matter was entirely consumed; the gases escaping at the extremity of the tube, and the asbestos at the same time preventing the possibility of any of the powder from being carried away mechanically by the current; the cock was then closed, and the tube allowed to cool. When cold it was weighed, and from the loss it was easy to calculate the per centage of combustible matter which is given in the tables.

It was found advantageous not to reduce the ashes, &c., to a very fine powder, for when in that state the high temperature caused the fusion of some of the inorganic substances, which prevented the complete combustion of the organic matters, by defending them from the action of the stream of oxygen.

Method for obtaining Water of uniform temperature in Boiler.

Considerable difficulty had been experienced during the former part of the investigation in obtaining the mean temperature of the water in the boiler at the beginning and end of an experiment; arising from the normal level being established by letting down water to the bottom of the boiler by means of the pipe E′, E′, E′, Plate II., and cold water being denser than hot, the cold water remained at the lower part of the boiler without mixing with that it already contained.

Experiments on this difference of temperature were frequently made, by reading off the thermometer L, and at the same time placing another thermometer in a stream of water issuing from the cock X, the water being first allowed to flow some considerable time in order that the pipe should become heated, and therefore not materially affect the temperature of the water flowing through it. By this means these two temperatures were found to vary on an average about 70°, which would make a considerable difference between the real and apparent weight of the water contained in the boiler; and as this is one of the elements employed in calculating the evaporative value of the coals experimented on, it was thought important to be able to find the true mean temperature.

In order to do this, the mixing apparatus, P, Q, R, S, Plate II., was put up: it consists of a force-pump, P, by means of which water can be drawn from the bottom of the boiler, and, passing in direction of the arrows α, α, α, β, β, β, be distributed on the top by means of the perforated extremities of the tubes T, T, T. In another position of the three and four-way cocks, R and S, the water passes directly from the tanks to the bottom of the boiler, as before the apparatus was put up; whilst by a third modification in the position of the plugs of the cocks R and S, the water can be made to flow directly on the top of the boiler from the tanks E, F, as shown by the arrows γ, γ, β, β.

This apparatus was after its erection used at the beginning and end of each experiment. The method of employing it was as follows:—

Supposing an experiment to have been made the previous day, the first thing done on arriving in the morning was to turn the cocks R and S in a proper position, and then, by means of the pump P, force water from the bottom of the boiler on the top at T, T, T, in the direction of the arrows α, α, β, β. This operation generally lasted ten minutes; when the cocks R and S being turned in another position, the normal level was restored by letting down water from the tanks in the direction of the arrows γ, γ, β, β, when the cold water flowing from

the apertures T, T, T, being denser than that contained in the boiler, falls to the bottom, but in doing so abstracts heat from the warm water through which it passes until the equilibrium is restored; the temperature is then read off by means of the thermometer L, and the cocks R and S turned in such a position that the water shall flow directly into the bottom of the boiler, and in the direction of the arrows γ, γ, γ, in which position they remain during the whole experiment. It is also necessary to shut the cocks T′, T′, T′, in order to prevent the condensation of steam in the apparatus, and cut off all communication with the boiler. By this means, the temperature of the water in the boiler becomes perfectly uniform throughout; for on placing a thermometer after the operation in a stream of water flowing from the cock X, a difference of two degrees between it and the thermometer L was rarely observed. These operations were repeated every morning during the progress of the experiments, as also on that of the fourth day, when the series of experiments was completed. This last temperature is used in the calculations of the work done on the third day, whilst in the other cases the final temperature of one day is evidently the initial temperature of the succeeding.

It might perhaps appear that a considerable portion of heat must be lost by radiation from the tubes Q, Q, Q, and Q′, Q′, Q′, during the process of pumping; but every precaution having been taken to prevent this, by covering them with felt, &c., it was sufficiently reduced as to produce no sensible effect on the results.

The cock X is also used for blowing off the water in order to cleanse the boiler; for since the water with which it is supplied contains on an average 20 grains of fixed matters in the gallon, and from three to four hundred gallons of water were daily blown off, the boiler becomes rapidly coated with a residue which would interfere with and modify the experiments, and therefore requires frequent removal.*

Another inconvenience which occurred during the former portion of the investigation arose from the difficulty of measuring with sufficient accuracy the quantity of water let down from the tanks during an experiment; as well as from the trouble of having to calculate from the measurement made each day the quantity used. In order to obviate this and render the apparatus more convenient, the water gauges, *e* and *f*, Plate III., were fitted to the tanks. They consist of bent glass tubes j′j′, connected with the tanks by means of the stop-cocks j‴ j‴, and were graduated by filling the tanks with water at the temperature of 70° Fah^{t}., and then weighing it out and marking the level on the tube after each weighing by means of a scratching diamond.

At each successive weighing, a hundred pounds were drawn off, and subdivisions made on the scale by measurement, as between these limits no errors of importance could occur. These graduations having been made at 70 Fah^{t}., it was taken as the normal temperature, and a Table formed, which will be found in another part of the Report, for the purpose of correcting the indications of the water guages whenever the thermometers of the tanks do not indicate that temperature.

Section II.—Experiments on the Evaporative Power of the Coals. By Professor Wilson and Mr. W. J. Kingsbury.

Museum of Economic Geology,
August 20, 1846.

Sir,

I beg to inform you that, in accordance with your instructions, I have been through the South Wales district, and have visited all the shipping ports, for the purpose of making myself acquainted with, and obtaining samples of those coals most approved of, and best adapted for steam purposes.

As the details of my report will necessarily be somewhat voluminous, I will now merely give you an outline of what I have done in the matter:—

I commenced my inquiry at Newport, where I found several coals well adapted for steam purposes; the principal were the Risca Veins, the Porthmawr, Cwm Brane, Tredegar Company's, the Duffryn, the Varleg, and others. I then proceeded to Cardiff, where I found Yniscynon, Merthyr, and Blaengwawr, the only coals shipped as steam coals: but there are others having a high repute as coking coals of first quality, which I think might, with much advantage, be included in our researches. At Porth Cawl, the next shipping port, there are at present only two sorts shipped, the Bryn-ddu and the Bethvos, both of excellent quality, the first being of a bituminous nature. At Tailbach and Port Talbot, the Rock Vawr Vein of Messrs. , with two others, belonging to the Governor and Company of Copper Mines, appear to be the only coals worth notice.

There are two coals shipped at Briton Ferry, but not suitable for steam purposes.

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* The analysis of this residue gave the following results:—

Carbonate of Lime	59·75
Sulphate	6·00
Phosphate	3·00
Silica	9·75
Peroxide of Iron	6·25
Carbonate of Magnesia	2·00
Alumina	2·87
Organic matters	10·35
Alkaline Chlorides	Trace
	99·97

J. A. P.

At Neath I found several sorts sold as steam coals; the Bryndowy Pwllfaron, Tyr Edemed, Abbey Gragola, Resolven, which, with several others, I have selected as best adapted for the purposes of this investigation. At Swansea also, I met with several free burning coals, amongst which I selected the Forest Graigola, the Pentripoth, the Graigola Company's, Colebrook Dale Company's, with a few others of good repute as steam coals.

The limit of my visit was Llanelly, where I also found several sorts of coal suitable for our purpose, and at the same time selected some samples from those coals usually considered unfit for steam purposes, as being too anthracitic. The free burning coals were the Llangenech, the Binea, Oldcastle Vein, Ward's Vein, and Webb's, with the anthracite coals of the Gilly Ceidrim, and Garnant mines. I think these last samples will be sufficient for our purposes, but that it will be very desirable to obtain also samples of those further advanced beds mined in the county of Pembroke. We shall then be in a position to determine the relative character of the four different conditions of the Welsh coal-field, viz., the bituminous, transition, or free burning, the anthracite, and the pure anthracitic.

Throughout the whole of my survey I found, both on the part of the proprietors and their agents, the greatest readiness to afford information, and desire to co-operate with us in this investigation, every one readily acknowledging its great importance to all parties concerned in the coal-trade of the country. The plan I pursued was to make myself acquainted with the coal-owners, explain to them the nature of this investigation, and invite them to furnish us with samples of their coals selected, subject to certain conditions which I have deemed it advisable to make, and which have met with perfect concurrence from all.

My stay in South Wales was limited to the shortest possible time, as I was anxious to return as speedily as possible, in order to get my boilers set, and the apparatus in proper working order.

Should it hereafter be deemed advisable to extend these researches to the various uses of coals in metallurgic and other manufacturing arts, I could then devote more time to the survey, and also obtain samples of those coals which, although well adapted for steam purposes, have nevertheless, from local disadvantages, not yet found their way into the market—of this description I am sure there will be found several sorts.

I have, &c.,

Sir H. T. De la Beche, London. (Signed) J. Wilson.

Pentrefelin Coal.

I hereby certify that the four casks, marked P.V., No. 1, contain a fair sample of the Pentrefelin coals, which were mined specially for the service of the "Admiralty Coals Investigation."—J. E. Morrice, *Agent for Swansea Coal Company.*

This coal is obtained near to the village, and in the parish, of Llangevelach, and is generally known by the name of the Clyndie, or 5 foot vein, and is worked at a depth from the surface of about 360 feet. The seam is about 4½ feet thick, and very regular throughout. The character of the subjacent stratum appears to be a soft undercliff, with 5 feet of cliff over the coal, covered by a thick bed of hard sandstone. The dip of the bed is 3½ inches in the yard; the direction 13° S.W. It is a free burning coal, and is used chiefly at the copper-smelting works in Swansea. The price through and through to the copper works is 41*s.* per 11 tons, being about 3*s.* 9*d.* per ton; if shipped as culm, the present price is 4*s.* 6*d.* The coal lies considerably north, and verges on the stone coal district; it makes very good culm for lime-burning. The sample of coal sent had been very loosely packed, and, being of a soft character, had become reduced into very small pieces, some even into a coarse powder. It has an indistinct fibrous structure with numerous horizontal plates of shaley matter, and also of a soft dark-coloured friable substance, chiefly along the line of bedding. A large part of the coal is made up of rectangular masses, which break up with a smooth, though not very bright, fracture. It is, however, a clean-looking coal, with but small quantities either of white substance or of iron pyrites.

Our remarks during the trials show that, owing to the extreme smallness of the coal, there was great difficulty both in lighting the fire and in getting the steam up: the same cause, no doubt, affected the trials throughout, as the work done was very small in comparison with that of other coals. As the fire burnt up, a distinct hissing noise was heard, and, on opening the fire door, large quantities of ignited particles, presenting a bright scintillating appearance, were carried over the fire bridge, and passed into the flues.

On stoking the fire, a considerable quantity of unburnt coal slipped through the bars, which, on being again thrown up, increased the difficulty of getting a good fire. The quantity of cinders and ashes left were consequently very large.

PENTREFELIN COAL.

	December 7, 1st day.	December 8, 2nd day.	December 9, 3rd day.
Fire lighted	8h. 15m.	8h. 20m.	
Steam up	10h. 20m.	10h. 30 m.	
Weight of Wood used	10 lbs.	15 lbs.	
Initial Temperature of Water in Boiler	162°	162°	
Temperature of Water in Tanks	35°	37°	
Barometer	..	..	
Extremes of external Thermometer	..	..	
Extremes of internal Thermometer	50°	52°	
Dew-point	..	..	
Area of Damper open	168 in.	168 in.	
Weight of Coals consumed	311 lbs.	311 lbs.	
Weight of Ashes left	27 lbs.	65 lbs.	
Per centage of combustible matter in Ashes	64·8	..	
Weight of Cinder left in lbs.	46 lbs.	31 lbs.	
Per centage of combustible matter in Cinder	30·87	..	
Weight of Clinker in Cinder	4 lbs.	2·3 lbs.	
Average weight of Soot in Flues	1·9 lbs.	..	
Per centage of combustible matter in Soot	51·45	..	
Weight of Water evaporated	1397 lbs.	1849 lbs.	
Weight of Water evaporated from 212° by 1 lb. of Coals	6·36 lbs.	6·36 lbs.	
Weight of Coals per hour for 1 square foot of grate surface	7·54 lbs.	7·99 lbs.	
Duration of Experiment	8 hrs.	8 hrs.	
Specific gravity of Coal	1·358	..	
Mean weight of cubic foot of Coal	66·16 lbs.	..	
Economic weight or space occupied by 1 ton	33·85 c. f.	..	
Cohesive power of Coal	52·7	..	

DUFFRYN COAL.

I hereby certify that the casks of coal, marked as in the margin of this certificate, contain a fair sample of the Duffryn steam coals, which were mined specially for the service of the "Admiralty Coals Investigation."—R. K. JONES, *Agent*.

The Duffryn steam coal is called the 4-feet vein, and is obtained in the valley of Aberdare, near Merthyr, in the county of Glamorgan. The depth of the pit is 288 feet, and the thickness of the vein is generally about 6 feet. It is worked in the form of stall and heading; the small and refuse is cast back, or gobbed in the stalls and waste; the large coal is filled into waggons, containing about a ton each, and conveyed from the stalls or heading to the top of the pit. The overlying stratum is strong clod or rock, and the subjacent stratum is strong fire clay and rock. The dip of the vein is 1 in 9, or 4 inches in the yard, and crops towards the north. It is described as a free burning coal; and its principal markets are London, Liverpool, Southampton, Dublin, and Plymouth. The distance from the colliery to Cardiff, the shipping port, is 22 miles, to which there is conveyance by both railroad and canal. No current price is given in the return, which states "that the coal has been shipped largely to the West Indies under contract with the Government for steam purposes, and has also been sent to the Mediterranean and America, and has given much satisfaction."

This is a coal of rather a soft description, easily breaking up into small pieces with a bright appearance of fracture, but which is somewhat obscured by the apparent irregularity of its structure. It contains a considerable proportion of a white substance, but no iron pyrites were observed in it. Some portions of the coal, where the structure is well seen, show the lines of fibrous structure as perpendicular to the planes of deposition or bedding. Numerous very thin layers of a soft brownish substance are seen along the line of bedding.

Our remarks during the trials show that it kindles very readily and burns freely, raising the steam with great rapidity. It makes a remarkably clean fire, without any smoke, opening well on the bars without caking. No clinkers were made; the ashes and cinders left were clean and of a whitish colour.

DUFFRYN COAL.

	December 10, 1st day.	December 11, 2nd day.	December 12, 3rd day.
Fire lighted	8h. 15m.	8h. 10m.	8h. 15m.
Steam up	9h.	9h. 15m.	9h. 20m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	200°	205°	209°
Temperature of Water in Tanks	42°	34°	33°
Barometer	..	..	..
Extremes of external Thermometer	..	..	..
Extremes of internal Thermometer	54—66°	48—62°	42—54°
Dew-point	..	..	..
Area of Damper open	112 in.	112 in.	112 in.
Weight of Coals consumed	337·5 lbs.	309·5 lbs.	321 lbs.
Weight of Ashes left	8·5 lbs.	11·5 lbs.	16·5 lbs.
Per centage of combustible matter in Ashes	52·76	..	..
Weight of Cinder left	8·5 lbs.	12.5 lbs.	12·5 lbs.
Per centage of combustible matter in Cinder	89·74	..	..
Weight of Clinker in Cinder	None.	None.	None.
Average weight of Soot in Flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in Soot	51·39	..	..
Weight of Water evaporated	2876 lbs.	2629 lbs.	2793 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	10·07 lbs.	10·07 lbs.	10·307 lbs.
Weight of Coals per hour for 1 square foot of grate surface	8·43 lbs.	7·74 lbs.	8·01 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·326	..	..
Mean weight of cubic foot of Coal	53·22 lbs.	..	..
Economic weight or space occupied by one ton	42·09 c. f.	..	..
Cohesive power of Coal	56·2	..	..

OLDCASTLE FIERY VEIN.

I, John Gibson, Agent for Messrs. Sims, Willyams, Nevill, Druce, and Co., hereby certify, that the casks 1 and 2, addressed to John Wilson, Esq., contain a fair sample of the Oldcastle Fiery Vein hand-picked coals, which were mined specially for the service of the "Admiralty Coals Investigation."

This coal is obtained close to the sea-side, within half a mile of the town of Llanelly, and is worked at a depth from the surface of about 336 feet. The seam is 2 feet 6 inches in thickness, and is very regular throughout. The overlying stratum is strong rock, and the subjacent strong fire clay. The dip of the seam is 4 to 5 inches in the yard, in a north and south direction; the strike of the bedding being east and west. The coal is of a bituminous character, and is worked nearly half large. The colliery is situate about one mile from the shipping port (Llanelly). The present market price is 6*s*. 6*d*. per ton as worked, and 9*s*. per ton if hand-picked large. England, Ireland, and France furnish the principal markets for the coal.

The sample of this coal has a dull lustrous appearance, similar to that of plumbago. It is a softish coal, with an imperfect fibrous structure, inclined at about 50° to the line of bedding, and contains very little pyrites or white matter. It breaks up readily into masses, having flat surfaces with irregular angles.

We remarked during the trial that, as soon as the fire burnt up and a high heat was obtained, a series of explosions, more or less loud, were heard throughout the day; being more frequent when fresh coal was thrown on, and gradually diminishing, both in intensity and frequency as the coal was consumed. The fire was readily kindled and burnt well, making but little smoke or dirt. On the fire the coal swells up immediately, opens well, and cakes just enough to hold the small pieces together, without obstructing the passage of air through the bars.

OLDCASTLE FIERY VEIN.

	December 21, 1st day.	December 22, 2nd day.	December 23, 3rd day.
Fire lighted	8h.	8h. 15m.	8h. 15m.
Steam up	10h. 45m.	8h. 45m.	8h. 40m.
Weight of Wood used	15 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	70°	206°	210°
Temperature of Water in Tanks	47°	37°	37°
Barometer	29·15 in.	29·10in.	28·76 in.
Extremes of external Thermometer	48°	..	33—39°
Extremes of internal Thermometer	50°	39—52	..
Dew-point	..	..	43°
Area of Damper open	112 in.	100 in.	112 in.

Oldcastle Fiery Vein—*continued.*

——	December 21, 1st day.	December 22, 2nd day.	December 22, 3rd day.
Weight of Coals consumed	365·5 lbs.	440 lbs.	438 lbs.
Weight of Ashes left	9 lbs.	9 lbs.	11·5 lbs.
Per centage of combustible matter in Ashes	33·15	30·79	..
Weight of Cinders left	16 lbs.	18·5 lbs.	17·5 lbs.
Per centage of combustible matter in Cinder	74·72	60·99	..
Weight of Clinker in Cinder	None.	None.	None.
Average weight of Soot in Flues	..	..	..
Per centage of combustible matter in Soot	..	..	..
Weight of Water evaporated	2259 lbs.	3327 lbs.	3451 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·65 lbs.	8·92 lbs.	9·72 lbs.
Weight of Coals per hour for 1 square foot of grate surface	10·44 lbs.	9·79 lbs.	9·72 lbs.
Duration of Experiment	7 hrs.	8 hrs.	9hrs.
Specific gravity of Coal	1·289	..	..
Mean weight of cubic foot of Coal	50·916 lbs.	..	..
Economic weight or space occupied by 1 ton	43·19 c.f.	..	..
Cohesive power of Coal	57·7	..	..

WARD'S FIERY VEIN.

I, John Gibson, Agent for Messrs. Sims, Willyams, Neville, Bruce, and Co., hereby certify, that the casks Nos. 3 and 4, addressed to John Wilson, Esq. contain a fair sample of Ward's Fiery Vein hand-picked coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JOHN GIBSON.

This colliery is situate about 1½ mile from the town of Llanelly, and 2½ miles from Loughor. The seam is 5 feet thick and very regular, and is worked at a depth of 426 feet from the surface. The strike is east and west, and rise north and south. The bottom stone is soft, the top a shaley blue stone, with a small quantity of iron-stone mixed. It has the character of a free burning coal, and works very large. The colliery is about 2 miles from the port of Llanelly. The present current price is 6*s*. 3*d*. per ton as worked, and 9*s*. per ton for hand-picked. The principal markets are in England.

This is a soft coal of a bright appearance, with a distinct fibrous structure, the direction of the lines of which is inclined to the planes of deposition, at an angle of about 45° across the planes of deposition; it appears to break very readily. Very little pyrites or white matter were seen in the sample of coal sent to us.

Our remarks during the trials are, that the fire was readily kindled, and that during the whole period of the experiments a hissing noise was distinctly heard in the fire, similar to that produced by throwing up wetted cinders or coals. The proportion of clinker was rather large, and of a reddish colour, containing much shale.

WARD'S FIERY VEIN.

——	December 28, 1st day.	December 29, 2nd day.	December 30, 3rd day.
Fire lighted	8hrs.	8h. 10m.	8h. 10m.
Steam up	9h. 30m.	8h. 40m.	8h. 35m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	110°	211°	212°
Temperature of Water in Tanks	33°	33°	33°
Barometer	30·55 in.	30·325 in.	30·645 in.
Extremes of external Thermometer	..	30°—32°	30°—38°
Extremes of internal Thermometer	38°—45°	44°—53°	45°—53°
Dew-point	..	..	..
Area of Damper open	112 in.	112 in.	112 in.
Weight of Coals consumed	484 lbs.	455 lbs.	414 lbs.
Weight of Ashes left	12 lbs.	9 lbs.	11 lbs.
Per centage of combustible matter in Ashes	23·6	15·01	15·51
Weight of Cinders left	19·5 lbs.	24 lbs.	22 lbs.
Per centage of Combustible matter in Cinder	..	27·16	..
Weight of Clinker in Cinder	7·43 lbs.	11·5 lbs.	14· lbs.
Average weight of Soot in Flues	1·06 lbs.	1·06 lbs.	1·06 lbs.
Per centage of Combustible matter in Soot	44·92	..	..
Weight of Water evaporated	3410 lbs.	3615 lbs.	3410 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·17 lbs.	9·36 lbs.	9·69 lbs.
Weight of Coals per hour for 1 square foot of grate surface	12·1 lbs.	11·37 lbs.	9·2 lbs.
Duration of Experiment	8 hrs.	8 hrs.	9 hrs.
Specific gravity of Coal	1·344	..	..
Mean weight of cubic foot of Coal	57·433 lbs.	..	..
Economic weight or space occupied by 1 ton	39· c. f.	..	..
Cohesive power of Coal	46·5	..	..

Binea Coal.

This coal was forwarded to London at an early stage of the investigation, and before the plan of examination was arranged, consequently no certificate of their quality was furnished.

This coal is obtained on Binea Farm, near Laughor Bridge, in the county of Glamorgan, and is known as the Binea or Loughor Fiery Vein. It is worked by the ordinary means of picks, and without blasting, at a depth of about 240 feet from the surface. The average thickness is about 4 feet, and the vein runs very regular, lying between strata of strong blue stone. It is but very slightly inclined. It is called a free burning coal, and appears to be used for locomotive and marine engines in the neighbouring ports and railways; large quantities are also sold in Ireland. The current price is 10*s.* per ton for large, and 7*s.* for the mixed and small. The colliery is about three miles from the port of Llanelly.

The sample of coal furnished had a bright appearance, with some surfaces distinctly fibrous, others very irregular, apparently made up of rectangular masses, separated by numerous thin layers of shaley matter. It is a soft coal, and contains but a very small quantity of pyrites or white matter. The surfaces of deposition are well marked, and average about $\frac{3}{4}$ of an inch apart. The lines of fibrous structure have an inclination of about 45° to the surface of deposition.

The only remarks made during the trials are, that both the cinders and the ashes left were of a reddish colour, and contained a large proportion of shaley matter, which, on being moved, broke down into a fine powder. No clinkers were found either on the bars or in the ash-pit.

Binea Coal.

	December 31, 1st day.	January 1, 2nd day.	January 2, 3rd day.
Fire lighted	8h. 40m.	8h. 15m.	8h. 15m.
Steam up	9h. 10m.	8h. 35m.	8h. 40m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	212°	218°	218·
Temperature of Water in Tanks	33°	33°	36°
Barometer	30·858 in.	30·33 in.	29·972 in.
Extremes of external Thermometer	22°—33°	28°—32°	32°—36°
Extremes of internal Thermometer	46°—51°	48°—51°	44°—55°
Dew-point	36°	42°	36°
Area of Damper open	56 in.	56 in.	56 in.
Weight of Coals consumed	384 lbs.	372 lbs.	366 lbs.
Weight of Ashes left	12·5 lbs.	11 lbs.	14·5 lbs.
Per centage of combustible matter in Ashes	16·42	30·18	47·8
Weight of Cinder left	20 lbs.	12 lbs.	18 lbs.
Per centage of Combustible matter in Cinder	36·41	47·87	66·85
Weight of Clinker in Cinder	None.	None.	None.
Average weight of Soot in Flues	1·45 lbs.	1·45 lbs.	1·45 lbs.
Per centage of Combustible matter in Soot	39·74	..	..
Weight of Water evaporated	3163 lbs.	3163 lbs.	3204 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coals	9·7 lbs.	9·93 lbs.	10·208 lbs.
Weight of Coals per hour for 1 square foot of grate surface	9·6 lbs.	9·3 lbs.	9·15 lbs.
Duration of Experiment	7 hrs.	8 hrs.	8hrs.
Specific gravity of Coal	1·304	..	..
Mean weight of cubic foot of Coal	57·08 lbs.	..	..
Economic weight or space occupied by 1 ton	39·24 c. f.	..	..
Cohesive power of Coal	51·2	..	..

Llangennech Coal.

The sample of these coals was furnished to the investigation through the hands of Messrs. Neville of Llanelly, and has been submitted to precisely the same treatment as those sent, either by those gentlemen, or by other proprietors. My application to the proprietors of this colliery for the usual particulars has not, however, been attended to, and I therefore am unable to include them in this Report.—J. W.

These coals have rather a dull appearance, are soft, and have a structure almost wholly fibrous, and contain minute quantities of iron pyrites, and but little white matter. Their fracture is very irregular, and the natural softness of the coals renders them easily reduced to powder (possibly this is the cause of their dull appearance). They appear to have a great disposition to break up into oblique angled masses: the fracture across the fibrous structure resembles that of antimony, only the grain is much coarser. Small thin plates of shaley matter occasionally occur, but of a very small size in general.

The remarks made during the trials are, that the ashes, cinders, and clinkers were of a reddish colour, containing much white and shaley matter; the clinkers were very thin, and when removed from the fire-bars and thrown on the fire, they were again burnt through with some difficulty. On treating the white matter of the clinker with acid hydrochloric, a strong odour of sulph. hydrogen was given out. They burnt very readily in a common house grate, leaving a lighter coloured ash.

LLANGENNECH COAL.

—	January 7, 1st day.	January 8, 2nd day.	January 9, 3rd day.
Fire lighted	8 hrs.	8h. 15m.	8 hrs.
Steam up	8h. 35m.	8h. 35m.	8h. 20m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	178°	214°	215°
Temperature of Water in Tanks	44°	44°	42°
Barometer	30·15 in.	30·175 in.	30·398 in.
Extremes of external Thermometer	41°—45°	41°—48°	35°—39°
Extremes of internal Thermometer	49°—55°	52°—55°	49°—55°
Dew-point	53°	46°	48°
Area of Damper open	49 in.	49 in.	49 in.
Weight of Coals consumed	304 lbs.	365 lbs.	342 lbs.
Weight of Ashes left	7 lbs.	12 lbs.	17 lbs.
Per centage of combustiole matter in Ashes	42·27	15·75	41·89
Weight of Cinder left	21 lbs.	27 lbs.	26 lbs.
Per centage of combustible matter in Cinder	83·79	56·83	39·64
Weight of Clinker in Cinder	9 lbs.	12 lbs.	10 lbs.
Average weight of Soot in Flues	75 lbs.	75 lbs.	75 lbs.
Per centage of combustible matter in Soot	38·67	..	..
Weight of Water evaporated	2465 lbs.	2629 lbs.	2588 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·91 lbs.	8·37 lbs.	8·32 lbs.
Weight of Coals per hour for 1 square foot of grate surface	7·6 lbs.	9·12 lbs.	8·55 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·312	..	..
Mean weight of cubic foot of Coal	56·93 lbs.	..	..
Economic weight or space occupied by 1 ton	39·34 c.f.	..	..
Cohesive power of Coal	53·5	..	..

MYNYDD NEWYDD.

I hereby certify that the two casks, marked M N, No. 3, contain a fair sample of the Mynydd Newydd coals, which were mined specially for the service of the "Admiralty Coals Investigation."—J. E. MORRIS, *Agent for Swansea Coal Company.*

This coal is generally known by the name of the Penyfilia or 5 feet vein, and is mined near Cadley, in the parish of Llangavelach. The vein varies from 5 feet to 7 feet in thickness, and is worked at a depth of 306 feet from the surface. The subjacent stratum is composed of soft cliff roof for 8 fathoms, with sandstone over. The inclination of the vein is 3 inches in the yard, and the direction 60° south-west. The coal is of a very bituminous character, and is used for household purposes generally, and also at the Copper Smelting Works, at Swansea, where the current price is about 5*s.* 6*d.* for the small, and 7*s.* 6*d.* per ton for the screened and shipping. It is much esteemed for house purposes, being considered very free from sulphur.

The sample of coal sent to us for trial was of a small size, having been badly packed and moved about from several places. It appeared, however, to be a moderately hard coal, of a compact structure, with an irregular fracture. The mass seemed to be made up of slightly rounded surfaces with a fine fibrous structure, the cross section of which presented a finely mottled appearance. The brown fibrous matter, so frequently met with, was found in small quantities, but no pyrites or white matter were seen.

The remarks at the trials were, that, owing to the smallness of the coals, they caked immediately on the fire, causing much smoke, and delaying the generation of steam. On moving the fire, much unburnt coal ran through the fire bars, and fell into the ash-pit. The proportions of clinkers, cinders, and ashes, were very considerable.

MYNYDD-NEWYDD.

—	January 11, 1st day.	January 12, 2nd day.	January 13, 3rd day.
Fire lighted	8h. 35m.	8h. 10m.	8h. 15m.
Steam up	9h. 20m.	8h. 35m.	8h. 35m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	188°	218°	218°
Temperature of Water in Tanks	34°	34°	37°
Barometer	30·25 in.	30·075 in.	29·924 in.
Extremes of external Thermometer	..	31°—36°	32°—35°
Extremes of internal Thermometer	47°—53°	45°—52°	48°—56°
Dew-point	37°·5	44°	48°
Area of Damper open	126 in.	126 in.	126 in.
Weight of Coals consumed	413 lbs.	377 lbs.	395 lbs.
Weight of Ashes left	14 lbs.	11 lbs.	12 lbs.
Per centage of combustible matter in Ashes	20·43	50·43	48·96
Weight of Cinder left	18 lbs.	21 lbs.	19 lbs.
Per centage of combustible matter in Cinder	35·46	58·38	42·34

Mynydd Newydd—*continued.*

	January 11, 1st day.	January 12 2nd day.	January 13, 3rd day.
Weight of Clinker in Cinder	9·14 lbs.	11·13 lbs.	11 lbs.
Average weight of Soot in Flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in Soot	41·31	..	..
Weight of Water evaporated	3368 lbs.	3040 lbs.	3140 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·83 lbs.	9·41 lbs.	9·34 lbs.
Weight of Coals per hour for 1 square foot of grate surface	10·32 lbs.	9·42 lbs.	9·67 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·31	..	..
Mean weight of cubic foot of Coal	56·33 lbs.	..	..
Economic weight or space occupied by 1 ton	39·76 c.f.	..	..
Cohesive power of Coal	53·7	..	..

THREE-QUARTER ROCK VEIN.

I hereby certify, that the three casks marked T Q R V S, contain a fair sample of the Three-quarter Rock Vein steam coals, which were mined especially for the service of the "Admiralty Coals Investigation."—THOMAS BLACK.

This is known as the Three-quarter Vein, and is situate near to the Varteg Iron Company's Works. It is obtained at a depth of from 210 to 240 feet from the surface; and the vein runs from 4 to 5 feet in thickness, and is worked in stalls and pillars. The subjacent and overlying strata are clunch coal, iron-stone, balt, clay, rock and iron-stone. The dip is 3½ inches in the yard in a westerly direction. The character of the coal is free burning, with a pure white ash, containing little sulphur, and working large. The colliery is 15¼ miles from the shipping port (Newport); the principal markets are the East and West Indies, Brazils, Africa and the Mediterranean ports, and the present price current is 9*s.* 6*d.* per ton.

This coal has a dull appearance, and is of a firm compact character, splitting readily along the bedding, which is often defined by layers of a soft brown matter. It breaks up very irregularly, the pieces are small, of a cubical shape with flat surfaces. The joints appear to be at right angles with the plane of deposition, and contain large quantities of pyrites, and a white substance of a hard, semi-crystalline appearance, which on being examined proved to consist chiefly of silica, with lime, magnesia, and traces of sulphur. The mass of the coal is composed of thin plates of coal, alternating with plates of shale. The sample, when received by us, seemed to have been exposed to rain, as the coal was in a very wet state.

Our remarks during the trials were, that the fire kindled freely but required a strong draught, making much smoke at first of a dense black nature, which, as the fire burnt up in the course of the day, assumed a reddish-brown tint. It caked quickly on the fire, and coked easily on the dead plate; much sooty matter was deposited on the top of the dead plate, and also in thin leaves adhering to the top of the fire-grate. The cinders and ashes, when thrown up, burnt well. The proportions of residua, ash, cinders, clinkers, and soot, were rather large. In a common fire-grate it burnt well, leaving a light-coloured ash.

THREE-QUARTER ROCK VEIN.

	January 14, 1st day.	January 15, 2nd day.	January 16, 3rd day.
Fire lighted	8h. 35m.	8h. 10m.	8h.
Steam up	9h.	8h. 35m.	8h. 20m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	217°	219°	219°
Temperature of Water in Tanks	36°	36°	36°
Barometer	30·064 in.	30·11 in.	30·096 in.
Extremes of external Thermometer	29°—39°	29°—38°	29°—36°
Extremes of internal Thermometer	48°—55°	45°—54°	48°—52°
Dew-point	45° 5	45°	40°
Area of Damper open	120 in.	132 in.	72 in.
Weight of Coals consumed	444 lbs.	470 lbs.	408 lbs.
Weight of Ashes left	9 lbs.	10 lbs.	12 lbs.
Per centage of combustible matter in Ashes	36·71	..	40·82
Weight of Cinder left	21 lbs.	18 lbs.	22 lbs.
Per centage of combustible matter in Cinder	50·09	..	80·96
Weight of Clinker in Cinder	10·12 lbs.	8 lbs.	7·14 lbs.
Average weight of Soot in Flues	1·5 lbs.	1·5 lbs.	1·5 lbs.
Per centage of combustible matter in Soot	43·77	..	..
Weight of Water evaporated	3394 lbs.	3533 lbs.	3081 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·91 lbs.	8·84 lbs.	8·79 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11.1 lbs.	11·75 lbs.	10·2 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·34	..	..
Mean weight of cubic foot of Coal	56·38 lbs.	..	..
Economic weight or space occupied by 1 ton	39·72 c.f.	..	..
Cohesive power of Coal	52·7	..	..

Graigola Coal.

No certificate; the coal having been sent up at the commencement of the investigation.—J. W.

This coal is known as the Graigola coal, and is obtained at Graigola, on the eastern side of the river Tawe, about six miles from Swansea, in the hamlet of Ynisymond, parish of Cadoxton juxta Neath. It is worked by short work—by holing in the under coal, and in the face of the slips; the object being to get as great a proportion as possible of large coal. The seams are worked by level, and are about 5 feet 9 inches in thickness, running very regular; both the under and overlying strata being a hard and solid sandstone. The inclination is about 3 inches to the yard, or 1 in 12, with a north rise. The coal is described as a free burning coal, with little smoke or sulphur. The current price is 10*s.* per ton for large hand-picked; the small is 3*s.* 6*d.* per ton. The principal markets are London, Mediterranean, Africa, Jamaica, and the various stations both at home and abroad. The coal appears to be used for making coke in open pits, and when mixed with a proportion of bituminous coal, is well adapted for smelting, &c.

The coal is of a soft character, tolerably bright appearance, and apparently fibrous structure, the lines being often inclined so as to form irregular cone-shaped masses, the general inclination being about 45° to the plane of deposition. Irregular patches of a soft brown substance are seen generally along the line of the bedding, with thin layers of a shaley nature. In the sample sent, no pyrites were observed, and but a very small quantity of whitish matter in the jointings.

Our remarks during the trials were, that the fire kindled easily and burnt well, though we had some trouble at first, owing to the small size of the coal. It had been very badly packed, and having been removed several times, its natural softness had caused it to separate into very small pieces. On the fire, the coal opens out well, but is apt to split into small pieces, which fall on the bars, and stop up the current of air, and, if moved, fall through to the ashpit. It seemed best to use pieces of a moderate size, and to leave them on the fire without much stoking. The ashes, cinder, and clinker were in considerable quantity, and of a very small size and reddish colour; the clinker being mixed up with scoria and dirt of a friable description. In a common grate it burnt well, leaving but very little ash.

Graigola Coal.

	January 18, 1st day.	January 19, 2nd day.	January 20, 3rd day.
Fire lighted	8h. 50m.	8h. 15m.	8h. 10m.
Steam up	9h. 20m.	8h. 40m.	8h. 30m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in boiler	190°	218°	218°
Temperature of Water in Tanks	34°	36°	36°
Barometer	30·155 in.	30·215 in.	30·1 in.
Extremes of external Thermometer	..	32°—39°	30°—36°
Extremes of internal Thermometer	45°—50°	45°—52°	45°—52°
Dew-point	38° 5	41°	42°
Area of Damper open	49 in.	49 in.	49 in.
Weight of Coals consumed	416 lbs.	364 lbs.	354 lbs.
Weight of Ashes left	10 lbs.	18 lbs.	21 lbs.
Per centage of combustible matter in Ashes	32·99	37·96	51·64
Weight of Cinder left	17 lbs.	17 lbs.	17 lbs.
Per centage of combustible matter in Cinder	60·57	38·66	39·74
Weight of Clinker in Cinder	6·5 lbs.	6 lbs.	3 lbs.
Average weight of Soot in Flues	1·25 lbs.	1·25 lbs.	1·25 lbs.
Per centage of combustible matter in Soot	46·24 lbs.	..	..
Weight of Water evaporated	3204 lbs.	2958 lbs.	2835 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·27 lbs.	9·47 lbs.	9·3 lbs.
Weight of Coal per hour for 1 square foot of grate surface	10·4 lbs.	9·1 lbs.	8·85 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs
Specific gravity of Coal	1·3	..	..
Mean weight of cubic foot of Coal	60·16 lbs.	..	..
Economic weight or space occupied by 1 ton	37·23 c.f.	..	..
Cohesive power of Coal	49·3	..	..

Park End Coals, Lydney.

I hereby certify that the 10 casks and boxes, marked Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, contain a fair sample of the best Park End coals, which were mined specially for the service of the "Admiralty Coals Investigation."—Thomas Nicholson, *Occupying Tenant of the Park End Colliery.*

This coal is known as the Park End High Delf or Lowry Vein, and is obtained at Park End, near Lydney, in the Forest of Dean. The vein is generally regular, and about three feet thick, and is worked long work, as in the thin veins of the Staffordshire coal-field. The overlying and subjacent strata are of the usual kind of shale. The dip varies from 6 inches to 2 feet in the yard, or from 1 in 6 to 2 in 3. The coal *is described* to be "of a free burning character of great strength and durability." The distance from the shipping port, Lydney, is

five miles. The current price in summer is 10*s.* per ton, in winter 11*s.*, free on board, and the principal markets are in Ireland, Cornwall, Cheltenham, and the manufacturing districts of Gloucestershire and Bridgewater.

The coal forwarded for investigation had a very hard and compact structure, with a clean and bright fracture, and contained iron pyrites in very large quarntities in every joint, even when broken down into the smallest sized pieces. It also contained to a considerable extent the white substance found in many of the other samples of coals sent to us. The bedding was very regular and well defined, along the planes of which the coal readily separated. The jointings appeared to be at right angles to the plane of deposition, where we usually found thin layers of a brown, soft, and silky substance, similar to that seen in other samples.

We remarked during the trials that the coal kindled easily, but that it made a very dirty smoky fire, which at the ordinary working draught caused immense volumes of dense smoke to appear at the chimney top. When the draught was increased the fire became clearer, but then the rush of smoke swept the loose soot from the flues and chimney, and carried it out in large flakes from the chimney top. If the draught was lessened, the fire would hardly burn, and on opening the doors the whole place was instantly filled with the loose ashes and smoke forced out from the fire. The cinders, ashes, and clinker were of a light weight and clean; the clinker contained much scoria, some of it quite vitrified. A palpable smell of sulph. hydrogen was perceived when the opening of the fire-doors caused the smoke to be driven into the boiler-house.

LYDNEY PARK END COAL.

	January 21, 1st day.	January 22, 2nd day.	January 23, 3rd day.
Fire lighted	8h. 30m.	8h. 15m.	7h. 55m.
Steam up	8h. 50m.	8h. 30m.	8h. 15m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	217°	219°	219°
Temperature of Water in Tanks	34°	38°	39°
Barometer	29·96 in.	29 824 in.	29·674 in.
Extremes of external Thermometer	32°—36°	35°—43°	32°—42°
Extremes of internal Thermometer	44°—52°	47°—55°	45°—57°
Dew-point	41°	45°	47°
Area of Damper open	144 in.	112 in.	112 in.
Weight of Coals consumed	478 lbs.	441 lbs.	451 lbs.
Weight of Ashes left	5 lbs.	4 lbs.	7 lbs.
Per centage of combustible matter in Ashes	31·14	37·52	31·82
Weight of Cinder left	9 lbs.	12 lbs.	18 lbs.
Per centage of combustible matter in Cinder	55·19	19·23	49·26
Weight of Clinker in Cinder	3·6 lbs.	4·6 lbs.	7·8 lbs.
Average Weight of Soot in Flues	1·25 lbs.	1·25 lbs.	1·25 lbs.
Per centage of combustible matter in Soot	35·15	..	..
Weight of Water evaporated	3673 lbs.	3286 lbs.	3081 lbs.
Weight of Water evaporated from 212° by 1 lb. of coal	8·99 lbs.	8·66 lbs.	7·93 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11·95 lbs.	11·02 lbs.	11·27 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·283	..	..
Mean Weight of cubic foot of Coal	54·44 lbs.	..	..
Economic weight or space occupied by 1 ton	41·14 c.f.	..	..
Cohesive power of Coal	55	..	..

PENTREPOTH COAL.

I hereby certify that the three casks, marked No. 2, contain a fair sample of the Pentrepoth coals, which were mined specially for the service of the "Admiralty Coals' Investigation."—J. E. MORRICE, *Agent for the Swansea Coal Company.*

This coal is generally called the 4 feet or Church Pit Vein, and is situate near Morriston, in the parish of Llangavelach. The vein runs about 4 feet thick, but is very irregular, and is worked at a depth from the surface of about 66 feet. The underlying stratum is soft cliff, with hard cliff over the beds. The dip is 6 inches in the yard, or 1 in 6, with a northerly direction. The coal is called free burning, and the current price at the copper works in Swansea, where alone it appears to be used, is about 44*s.* per 11 tons, or 4*s.* per ton. The distance of the colliery from the port is 3½ miles.

The sample of this coal sent appeared to have been badly packed, as the coal, being soft, was broken up into very small pieces. It appeared to be of a bright fibrous structure, but not so distinctly so as many other sorts sent up to us for investigation: the peculiar cone-shaped form being however well defined. The coal was of a very soft character, containing thin laminæ of a very bright coal, somewhat firmer in structure. In the bedding a dark-brown soft substance was found, but otherwise the body of the coal was very clean, and free both from pyrites and the white substance so frequently met with.

Our remarks during the trials are, that the Pentrepoth coal burnt with great difficulty, unless a deep fire is kept up, and the charge continually thrown on the top of the fire in very small quantities at a time. Little or no smoke was given off, and a very high local temperature was produced by the combustion of the large quantity of coal on the fire bars. The same

scintillations were seen throughout the the trials, as with the Pontrefelin coal, and also the same hissing noise while burning. More wood was necessary to light up with than usual. The ashes, cinders, and soot, were also in large proportions, though much of the latter was blown away while raking out the flues.

PONTREPOTH COAL.

—	January 25, 1st day.	January 26, 2nd day.	January 27, 3rd day.
Fire lighted	9hrs.	8h. 15m.	8h. 15m.
Steam up	9h. 50m.	9hrs.	8h. 45m.
Weight of Wood used	15 lbs.	15 lbs.	15 lbs.
Initial Temperature of Water in Boiler	185°	194°	216°
Temperature of Water in Tanks	43°	43°	45°
Barometer	29·39 in.	29·494in.	29·47 in.
Extremes of external Thermometer	..	39°—43°	43°—47°
Extremes of internal Thermometer	50°—53°	51°—58°	52°—59°
Dew-point	43°	44°	47°
Area of Damper open	126 in.	56 in.	56 in.
Weight of Coals consumed	357 lbs.	375 lbs.	319 lbs.
Weight of Ashes left	13 lbs.	8 lbs.	11 lbs.
Per centage of combustible matter in Ashes	37·75	38·97	38·78
Weight of Cinder left	27 lbs.	22 lbs.	25 lbs.
Per centage of combustible matter in Cinder	49·94	52·28	39·67
Weight of Clinker in Cinder	14·25 lbs.	10·5 lbs.	12·9 lbs.
Average weight of Soot in Flues	1·125 lbs.	1·125 lbs.	1·125 lbs.
Per centage of combustible matter in Soot	48·62	..	..
Weight of Water evaporated	2463 lbs.	2758 lbs.	2538 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·3 lbs.	8·72 lbs.	9·14 lbs.
Weight of Coals per hour for 1 square foot of grate surface	8·92 lbs.	9·37 lbs.	7·27 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8hrs.
Specific gravity of Coal	1·31	..	..
Mean weight of Cubic foot of Coal	57·72 lbs.	..	..
Economic weight or space occupied by 1 ton	38·8 c. f.	..	..
Cohesive power of Coal	46·5	..	..

CWM FROOD ROCK VEIN.

I hereby certify that the three casks, marked C.R.V.S., contain a fair sample of the Cwm Frood Rock Vein steam coals, which were mined specially for the service of the "Admiralty Coals Investigations."—THOMAS BLACK.

This coal is obtained at Cwm Frood near to the works of the Varteg Iron Company. The vein runs from 5 to 6 feet in thickness, is very regular, and is worked in stalls and pillars at a depth of 270 to 300 feet from the surface. The strata in which it lies are clunch coal, iron-stone, clay-coal, fire-clay, and rock; the dip being about 3½ inches in the yard, and in a westerly direction. The colliery is about 15 miles from Newport, the port at which it is shipped. The principal markets are, the Brazils, East and West Indies, Africa, and the Government contracts, in which it was admitted about four years ago. The price current is 9*s*. 6*d*. per ton.

The general appearance of this coal was dull, with iridescent plates of iron pyrites and opake white plates on its surface. In the planes of deposition or bedding, a dull brown matter of a soft pulverulent character, containing small white particles, was seen in some quantity. The coal was of a much harder structure than most others that we have had from the South Wales basin, and had a very irregular fracture, though with a great tendency to separate into small rectangular masses. It appeared to be made up of layers of shaly matter, alternating with thin layers of bright coal, and split up easily, though irregularly, along the planes of deposition. Large quantities, both of pyrites and white substance, were found disseminated through the entire mass, showing themselves chiefly in the jointings.

Our remarks during the experiments were only, that the fire appeared dirty and smoky, and that at times large quantities of smoke were seen from the chimney, and that a large proportion of soot was obtained from the flues of a very dark colour and very light weight.

CWM FROOD ROCK VEIN.

—	January 28, 1st day.	January 29, 2nd day.	January 30 3rd day.
Fire lighted	8h. 40m.	8h. 15m.	8h. 15m.
Steam up	9h. 10m.	8h. 35m.	8h. 40m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	214°	217°	216°
Temperature of Water in Tanks	46°	46°	39°
Barometer	29·152 in.	29·414 in.	29·54 in.
Extremes of external Thermometer	43°—47°	35°—43°	29°—46°
Extremes of internal Thermometer	52°—58°	47°—57°	46°—54°

Cwm Frood Rock Vein—*continued.*

	January 28, 1st day.	January 29, 2nd day.	January 30, 3rd day.
Dew-point	45·5°	44·5°	45·5°
Area of Damper open	..	..	..
Weight of Coals consumed	333 lbs.	340 lbs.	374 lbs.
Weight of Ashes left	7· lbs.	7· lbs.	9· lbs.
Per centage of combustible matter in Ashes	46·27	38·9	27·45
Weight of Cinders left	18 lbs.	16 lbs.	21 lbs.
Per centage of combustible matter in Cinder	17·72	32·89	35·64
Weight of Clinker in Cinder	4·8 lbs.	5· lbs.	8· lbs.
Average weight of Soot in Flues	1·3 lbs.	1·3 lbs.	1·3 lbs.
Per centage of combustible matter in Soot	52·41	..	..
Weight of Water evaporated	2479 lbs.	2571 lbs.	2812 lbs.
Weight of Water evaporated from 2128 by 1 lb. of Coal	8·63 lbs.	8.73 lbs.	8·75 lbs.
Weight of Coals per hour for 1 square foot of grate surface	8·32 lbs.	8·5 lbs.	9·35 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·255	..	..
Mean weight of cubic foot of Coal	55·27 lbs.	..	..
Economic weight or space occupied by 1 ton	40·52 c. f.	..	..
Cohesive power of Coal	72·5	..	..

Anthracite.

This coal was forwarded to London at the commencement of the investigation, and before any distinct plans of operation were decided upon; consequently no certificate was furnished with it.—J.W.

This coal is obtained in the parish of Llanguicke, in the county of Glamorgan, and is known by the name of the Brass Vein of the Cwmllynfell Colliery. It is worked at a depth of 318 feet from the surface, the galleries extending for some distance to the crop of the vein, the stalls most to the rise being about 226 feet from the surface. It is called a 4-feet vein, and is about 3 feet 10 inches in thickness, and very regular. The dip in general is from 5 to 6 inches in the yard, and in a southerly direction; however, there are several pans and saddles which at intervals change the inclination and direction. There is also one extensive fault running nearly north and south. The overlying and subjacent strata appear to be argillaceous shales, interspersed with other veins of coal, and several veins of iron-stone and fire-clay.

The character of the coal is anthracite, and it is chiefly used in the hop and malt districts of England; the small coal is used also for lime-burning. The colliery is about 16 miles from the port of Swansea, where the current price is 12*s.* to 13*s.* per ton for the large, and 5*s.* to 6*s.* per ton for the small. There appear to be several other veins of anthracite coal in the neighbourhood. This vein is liked best for the malt and hop-kilns, though a 6-feet vein, called the Big Vein, and a 3-feet vein, called the Little Vein, are most preferred for iron-smelting. This "Brass Vein" takes its name from a vein of pyrites, ¼ to 3 inches thick, which runs through it; the coal in its immediate vicinity is considered by the colliers to be brighter, harder, and purer than any other portion of the vein.

This anthracite coal has a bright appearance, with a shining irregular fracture; the bedding is tolerably well defined, with layers of a soft brown substance at a considerable distance from each other. It breaks with a semi-vitreous fracture into irregular very brittle masses. Although the structure of the coal is hard, still, from its brittle character, it is without difficulty broken up into small pieces.

We remarked on the first day's trial, that it was with great difficulty that we got the coal sufficiently kindled to get the steam up, nearly three hours intervening between the time of lighting up and that of getting up the steam; we therefore found it necessary on the following days to increase our quantity of wood, and also to use a given weight of another description of coal, in order to obtain that temperature which the anthracite appears to require before it will enter into combustion. When once that takes place, the heat given off is intense, and the fire is very readily sustained. It is very advisable to supply the coal in small pieces, about the size of an egg, and gradually to raise their temperature by throwing them on the dead plate first, and thence on to the fire; by such means we materially prevent that splitting into small pieces, which the sudden application of a great heat is sure to occasion in all coal of the same structural composition as the anthracites. The quantities of cinders and ashes were larger than with many other coals; they were of very small size, and both contained, when broken up and examined, varying proportions of pure and unaltered coal surrounded by the burnt mass. The clinker was very small in quantity, and in very small and very hard pieces. The fire kept burning for an unusually long time after the firing had ceased, as seen by the working sheet for the first day's trial; we left off charging at 5h. 45m.; the steam, however, was blowing off up to 10 p. m., and the fire remained in up to 10h. 45m.

ANTHRACITE.

	February 1, 1st day.	February 2, 2nd day.	February 8, 3rd day.
Fire lighted	8h. 40m.	8. 45m.	9h.
Steam up	11h. 15m.	9h. 45m.	10h. 40m.
Weight of Wood used	10 lbs.	15 lbs.	10 lbs.
Initial Temperature of Water in Boiler	180°	214°	189°
Temperature of Water in Tanks	37°	40°	35°
Barometer	29·57 in.	29·87 in.	29·65 in.
Extremes of external Thermometer	..	31 — 3 °	..
Extremes of internal Thermometer	45—50°	45—51°	43—50°
Dew-point	40°·5	40°·5	38°
Area of Damper open	56 in.	56 in.	56 in.
Weight of Coals consumed	363 lbs.	336 lbs.	340 lbs.
Weight of Ashes left	8 lbs.	19 lbs.	10 lbs.
Per centage of combustible matter in Ashes	22·65	28·57	49·14
Weight of Cinder left	18 lbs.	23 lbs.	18 lbs.
Per centage of combustible matter in Cinder	44·66	30·07	37·13
Weight of Clinker in Cinder	None.	..	.
Average weight of Soot in Flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in Soot	42·82	..	..
Weight of Water evaporated	2734 lbs.	3024 lbs.	2857 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·19	9·74	9·46
Weight of Coals per hour for 1 square foot of grate surface	9·07 lbs.	8·4 lbs.	8·49 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·375	..	..
Mean weight of cubic foot of Coal	58·25	..	..
Economic weight or space occupied by 1 ton	38·45 c. f.	..	..
Cohesive power of Coal	68·5	..	..

CWM NANTY-GROS.

No certificate has been received respecting these coals.—J. W.

The sample of coal sent up for the trials was of a softish character, the bedding well-defined, with laminæ of shaly matter, varying in thickness, and of great hardness, with irregular plates of a brownish-black substance of a soft and silky appearance. The general structure of the coal was very irregular, and large quantities of pyrites of a light colour were perceptible throughout the mass, together with a smaller quantity of a white substance, like that met with in several of the other coals, but not in such large and flat plates.

The coal broke up easily into small pieces; it kindled readily, and seemed to coke well upon the dead plate, making rather a smoky fire, which, however, by careful stoking and regulation of draught, did not appear at the chimney top as smoke. No other remarks were made during the experiments.

CWM NANTY-GROS.

	February 4, 1st day.	February 5, 2nd day.	February 6, 3rd day.
Fire lighted	8h. 15m.	8h. 15m.	8h. 15m.
Steam up	8h. 45m.	8h. 40m.	8h. 40m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	183°	215°	216°
Temperature of Water in Tanks	36°	37°	43°
Barometer	30·20 in.	30·16 in.	29·68 in.
Extremes of external Thermometer	32—35°	29—40°	38—43°
Extremes of internal Thermometer	43—51°	45—53°	49—57°
Dew-point	42°·5	43°	48°·5
Area of Damper open	84 in.	12·6 in.	84· in.
Weight of Coals consumed	414 lbs.	369 lbs.	370 lbs.
Weight of Ashes left	7 lbs.	6 lbs.	7 lbs.
Per centage of combustible matter in Ashes	18	11·71	21·78
Weight of Cinder left	13 lbs.	12 lbs.	13 lbs.
Per centage of combustible matter in Cinder	30·57	36·25	31·09
Weight of Clinker in Cinder	4·11 lbs.	4·3 lbs.	3·8 lbs.
Average weight of Soot in Flues	1·56 lbs.	1·56 lbs.	1·56 lbs.
Per centage of combustible matter in Soot	39·45	..	..
Weight of Water evaporated	2853 lbs.	2734 lbs.	2605 lbs.
Weight of Water evaporated from 21° by 1 lb. of Coal	8·38 lbs.	8·65 lbs.	8·23 lbs.
Weight of Coals per hour for 1 square foot of grate surface	10·34 lbs.	9·24 lbs.	9·24 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
[illegible] gravity of Coal	1·28	..	..
[illegible] foot of Coal	56· lbs.	..	..
occupied by 1 ton	40· c. f.	..	..
	55·7	..	..

Wylam's Patent Fuel.

This patent fuel was purchased of the company from the stock with which the market was at the time supplied, and therefore no certificate was required.—J. W.

It is made and sold in blocks, weighing about 13 lbs. each, of an oblong rectangular shape, being 12″ × 6″ × 5″. The charge-box, used for taking the economic weight of a cubic foot of coal, not being adapted for these blocks, we took 24 of them, and built them up so as to form a parallelopiped 24″ × 20″ × 18″, and then found it to weigh 329 lbs., which gives $\frac{329}{5} = 65{\cdot}8$ lbs. per cubic foot. The blocks, when broken, show an irregular fracture, and appear to be composed of small pieces of coal forcibly compressed and cemented together by some bituminous substance, giving off a strong odour of mineral pitch when heat is applied to them.

Our remarks during the trials show, that the fire was readily kindled and steam quickly got up, but much smoke always appeared in the fire, though with a slow draught, but little was seen from the chimney. The fuel swells up on the fire, and separates from the mass in large flakes, which are readily burnt, leaving a fresh surface for the action of the fire.

The proportions of cinders, ashes, and clinkers were considerable; the ashes having a reddish colour, containing much very small clinkers. The soot also was in large quantities, and no doubt with a quicker draught would have produced much smoke.

Wylam's Patent Fuel.

	February 11, 1st day.	February 12, 2nd day.	February 13, 3rd day.
Fire lighted	8 hrs.	8h. 10m.	8h. 10m.
Steam up	9 hrs.	8h. 30m.	8h. 35m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boilers	160°	214°	214°
Temperature of Water in Tanks	33°	34°	34°
Barometer	29·77 in.	29·92 in.	30·07 in.
Extremes of external Thermometer	20°—30°	13°—31	21°—30°
Extremes of internal Thermometer	40°—47°	39°—47°	39°—41°
Dew-point	39°·5	37°	44°
Area of Damper open	140 in.	84 in.	84 in.
Weight of Coals consumed	418 lbs.	330 lbs.	380 lbs.
Weight of Ashes left	7·5 lbs.	8 lbs.	10·5 lbs.
Per centage of combustible matter in Ashes	37·32	25·52	32·41
Weight of Cinder left	19 lbs.	15 lbs.	17 lbs.
Per centage of combustible matter in Cinder	44·58	55·57	42·31
Weight of Clinker in Cinder	11·14 lbs.	9 lbs.	10 lbs.
Average weight of Soot in Flues	1·37 lbs.	1·37 lbs.	1·37 lbs.
Per centage of combustible matter in Soot	43·73	..	..
Weight of Water evaporated	2853 lbs.	2660 lbs.	2894 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·76 lbs.	9·04 lbs.	8·97 lbs.
Weight of Coals per hour for 1 square foot of grate surface	10·2 lbs.	8·24 lbs.	9·48 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·10	..	..
Mean weight of cubic foot of Coal	65·08 lbs.	..	..
Economic weight or space occupied by 1 ton	34·41 c. f.	..	..
Cohesive power of Coal	70·	..	..

Grangemouth Coals.

I hereby certify that the 3 casks, addressed "John Wilson, Esq., College, Civil Engineers, Putney," contain a fair sample of the Grangemouth Coal Company's Main Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—Geo. G. Mackay, *Manager*.

This coal is called the main coal, or Carronhall splint, and is mined in the parish of Bothkennar, half a mile from Grangemouth. It is worked long-wall, at a depth of 270 feet from the surface, and varies from 3 feet to 3 feet 4 inches in thickness. The dip of the bedding is from 1 in 10 to 1 in 12, and the subjacent and overlying strata are composed of shale, faike, or laminated sand stone, coal, fire-clay, and sand-stone. The character given of the coal is, "that it is composed chiefly of splint, with a portion of cherry or cubical coal on the top; that it burns with an intense heat without caking; that it is free from sulphur, and leaves a light-coloured ash." The distance from the port, Grangemouth, is half a mile, and the current price is 9*s*. per ton. The principal markets are the Baltic and France for steam purposes, and the neighbouring districts for iron-smelting, &c.

The sample of coal sent us was from the main coal, south working of the Grangemouth Colliery; it is a coal of a dull appearance, and so hard as to require a sledge-hammer to break it up, but splits readily in the direction of the bedding. Across that line, the fracture is very irregular; it contains large quantities of a very hard shaly matter, varying in thickness up to 3 and 4 inches, and sometimes intermixed with thin laminæ of bright black coal; the shaly matter burns and leaves a dense whitish residuum. The coal in appearance shows out little pyrites, but numerous plates of a white substance, of a greater thickness than has

been observed in any other coal; it always contains a considerable quantity of the soft friable substance which gives such a curious silk-like play to reflected light.

Our remarks during the trials would show that it lights up readily, and although it makes a smoky fire, still but little smoke was seen escaping from the chimney, save when the draught was altered at the time of firing. The pure coal swells and breaks up well on the fire, but the shaly matter splits and flies on the application of heat. On the first day of the trials, towards the latter part of the day, on the ashpit being opened, a large quantity of flame and smoke was forced down through the fire-bars, escaping out of the ashpit-door into the boiler-house; this occurred twice the same day, but not on either of the subsequent days. The ashes were very small, like dust, and of a whitish colour, the cinders and clinker were also of the same colour.

GRANGEMOUTH COAL.

—	February 15, 1st day.	February 16, 2nd day.	February 17, 3rd day.
Fire lighted	8h. 40m.	8h.	8h. 10m.
Steam up	9h. 15m.	8h. 25m.	8h. 35m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	191°	216°	216°
Temperature of Water in Tanks	43°	43°	44°
Barometer	29·43 in.	29·84 in.	29·95 in.
Extremes of external Thermometer	..	37°—45°	43°—47°
Extremes of internal Thermometer	45°—58°	46°—58°	52°—61°
Dew-point	50°	48°	52°
Area of Damper open	140 in.	84 in.	84 in.
Weight of Coals consumed	443 lbs.	386 lbs.	402 lbs.
Weight of Ashes left	8 lbs.	7 lbs.	9 lbs.
Per centage of combustible matter in Ashes	45·45	14	34·05
Weight of Cinder left	12 lbs.	11 lbs.	12 lbs.
Per centage of combustible matter in Cinder	46·22	63·4	41·66
Weight of Clinker in Cinder	3·14 lbs.	4 lbs.	2 lbs.
Average weight of Soot in Flues	1·9 lb.	1·9 lb.	1·9 lb.
Per centage of combustible matter in Soot	46·43	..	..
Weight of Water evaporated	2857 lbs.	2398 lbs.	2530 lbs.
Weight of Water evaporated from 212° by 1lb. of Coal	7·72 lbs.	7·2 lbs.	7·29 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11·07 lbs.	9·63 lbs.	10·03 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·29	..	..
Mean weight of cubic foot of Coal	54·25 lbs.	..	..
Economic weight or space occupied by 1 ton	40·13 c. f.	..	..
Cohesive power of Coal	69·7	..	..

BROOMHILL COALS.

I hereby certify that the ten boxes, marked Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, contain a fair sample of the Broomhill Colliery coals, which were mined specially for the service of the "Admiralty Coals Investigation."—FRANCIS CARR, *Manager*.

This colliery is situate at Broomhill, on the Chevington estate of the Earl Grey, and lies about 24 miles N.N.E. from Newcastle, 9 miles N.N.E. from Morpeth, 9½ miles S.S.E. from Alnwick, and 3 miles S. from Warkworth, which is the port at which the coal is shipped. There are two workable pits: the one now in work is called the "Low Main Coal Seam," which is worked at a depth of 204 feet from the surface, and averages about 5 feet 10 inches in thickness, all clean coal, save a thin piece of splint coal at the top of the seam. It is worked "board and pillar," in contradistinction from "long work." The dip is about 1 in 12, or 4¾°, and runs about S. 44° E. The overlying strata appear to be clay, an argillaceous blue stone, and a grey coloured sand-stone, very strong and hard, which is also continued underneath the present workings.

The character of the coal given is, "bituminous, open burning, leaves little earthy residue, is a prime steam coal, being of a very quick and intense heating power." The current price is 3*s*. 4*d*. per ton at the pit, the sale at present being confined to the neighbouring markets. In the general remarks it is stated, "That the extent of the coal field is estimated at 5000 acres: that there are two other good marketable seams, the High Main Seam, 4 feet 9 inches thick, at a depth of 102 feet, and the Yard Coal Seam, 3 feet 2 inches thick, at a depth of 246 feet, all running parallel to each other over a great part of the said area. There is scarcely any fire-damp or carb. hydrogen."

The sample of Broomhill coal sent up for examination showed that the coal was of a very hard description, but readily splitting in the planes of deposition. The structure of the coal varied considerably; hard thin plates of very bright black coal, having, when broken, somewhat of a conchoidal fracture, alternating with hard dull-looking shaly laminæ, and patches of soft friable material, having the silky appearance so often observed. There appeared to be a very considerable quantity of pyrites in the jointings, which, though in thickness considerable enough to show distinct crystals, did not appear to exist disseminated through the entire mass. Small patches of white matter were also seen in detached plates.

Our remarks during the experiments are, that this coal lights up very readily, burns briskly, with a crackling noise, and makes a very dirty fire, with a dull flame; yet, when the draught is well arranged, but little smoke escaped from the chimney. The ashes and cinders were of a whitish colour, and the clinkers left in very small pieces.

BROOMHILL COAL.

—	March 1, 1st day.	March 2, 2nd day.	March 5, 3rd day.
Fire lighted	8h.	8h. 15m.	8h.
Steam up	8h. 45m.	8h. 55m.	8h. 40m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	172°	216°	163°
Temperature of Water in Tanks	36°	38°	42°
Barometer	30·37 in.	30·54 in.	30·32 in.
Extremes of external Thermometer	..	32°—38°	39°—41°
Extremes of internal Thermometer	43°—°50	47°—55°	48°—53°
Dew-point	40°	42°·5	43°
Area of Damper open	140 in.	84 in.	84 in.
Weight of Coals consumed	520 lbs.	360 lbs.	432 lbs.
Weight of Ashes left	5 lbs.	6 lbs.	5·5 lbs.
Per centage of combustible matter in Ashes	38·56	69·9	59·97
Weight of Cinder left	7 lbs.	6 lbs.	6 lbs.
Per centage of combustible matter in Cinder	48·21	38·43	49·94
Weight of Clinker in Cinder	3·6 lbs.	·75 lbs.	None.
Average Weight of Soot in flues	2 lbs.	2 lbs.	2 lbs.
Per centage of combustible matter in Soot	55·45	..	..
Weight of Water evaporated	3017 lbs.	2326 lbs.	2519 lbs.
Weight of Water evaporated from 212° by 1 lb of Coal	8·55 lbs.	9·02 lbs.	8·7 lbs.
Weight of Coals per hour for 1 square foot of grate surface	10·83 lbs.	7·5 lbs.	9· lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·25	..	..
Mean weight of cubic foot of Coal	52·5 lbs.	..	..
Economic weight or space occupied by 1 ton	42·67 c. f.	..	..
Cohesive power of Coal	65·7	..	..

RESOLVEN COALS.

We hereby certify that the two casks, marked John Wilson, Esq., contain a fair sample of the Resolven Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JEVONS and WOOD, *Agents to J. W. Lyon, Esq.*

This coal is known as the Garrylwyd Seam, and is obtained in the Resolven Wood, in the Vale of Neath. It is worked by level, cross headings and stalls, at a distance from the surface of 600 feet. The dip or inclination is 3 inches in the yard, or 1 in 12, with a westerly direction; the thickness of the seam being 2 feet 6 inches, and rather irregular. The price current is 10*s.* per ton; the principal markets being the Government depôts. The colliery is about 9 miles from the port of Neath.

This sample of coal is very soft, has rather a dull appearance, and breaks up with a very irregular fracture. In many places the structure is distinctly fibrous, and in a few instances the lines tend towards a point assuming a conical form. Where the fibrous structure is well shown, the coal resembles good iron cut across the grain; the cross section often showing circular tables having a brilliant lustre. The bedding is well defined by the brown matter so often met with in coals; but there appears to be a much greater tendency to break in directions inclined to the bedding than parallel to it. The coal is readily broken up into irregular oblique rhombs, and the exposed surfaces contain a considerable quantity of white matter, together with a smaller quantity of pyrites.

During the trials, we found that the coal kindled readily, caking slightly on the dead plate; on the fire it swelled up and soon split, making a strong open fire. The fire was throughout very clear, and only a small quantity of reddish brown smoke was seen occasionally at the chimney top. The ashes and cinders left were in small quantities, well burnt, and of a whitish appearance. The soot found in the flue was very heavy, and of a light colour, owing to small ashy matter having been carried over and mixed with it.

RESOLVEN COAL.

—	March 15, 1st day.	March 16, 2nd day.	March 17, 3rd day.
Fire lighted	11h. 45m.	8 h. 15m.	8h. 15m.
Steam up	12h. 45m.	8h. 30m.	8h. 30m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	160°	216°	217°
Temperature of Water in Tanks	47°	44°	47°
Barometer	30·23 in.	29·9 in.	29·83 in.

Resolven Coal—*continued.*

	March 15, 1st day.	March 16, 2nd day.	March 17, 3rd day.
Extremes of external Thermometer.	..	48°—°52	46°—°56
Extremes of internal Thermometer.	52°—°60	52—54°	56°—70°
Dew-point	46°	48·5	50°
Area of Damper open	84 in.	56 in.	56 in.
Weight of Coals consumed	369 lbs.	314 lbs.	300 lbs
Weight of Ashes left	7·5 lbs.	7 lbs.	7·5 lbs.
Per centage of combustible matter in Ashes	78·7.	53·46	42·86
Weight of Cinder left	9·5 lbs.	5 lbs.	7 lbs.
Per centage of combustible matter in Cinder	63·68	70·78	71·31
Weight of Clinker in Cinder	None.	..	..
Average weight of Soot in Flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in Soot	41·	..	..
Weight of Water evaporated	2521 lbs.	2857 lbs.	2481 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·53 lbs.	10·52 lbs.	9·54 lbs.
Weight of Coals per hour for 1 square foot of grate surface	9·24 lbs.	7·44 lbs.	7·5 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·32	..	..
Mean weight of cubic foot of Coal	58·66 lbs.	..	..
Economic weight or space occupied by 1 ton	38·19 c. f.	..	..
Cohesive power of Coal.	35·	..	..

SUMMARY.

Names of Coals employed in the Experiments.	Evaporating power, or number of pounds of Water evaporated from 212° by 1 lb. of Coal (economic).	Weight of 1 cubic foot of the Coal as used for fuel. — Lbs.	Weight of 1 cubic foot of the Coal as calculated from the density. — Lbs.	Ratio of B. to C., or of the economical to the theoretical weight.	Difference per cent. between theoretical and economical weights.	Space occupied by 1 ton in cubic feet (economic weight.)	Results of experiments on cohesive power of Coals per centage of large Coals.	Evaporating power of the Coal, after deducting for the combustible matter in the residue.	Per centage of residue in the Coals. — Mean.
	A.	B.	C.	D.	E.	F.	G.	H.	I.
Pentrefelin	6·36	66·166	84·726	·781	28·051	33·85	52·7	7·4	27·7
Dyffryn	10·149	53·22	82·72	·643	55·43	42·09	56·2	11·80	7·81
Old Castle Fiery Vein	8·94	50·916	80.42	·633	57·946	43·99	57·7	..	6·57
Binea	9·446	57·08	81·357	·702	42·53	39·24	51·2	10·3	8·22
Mynydd Newydd	9·52	56·33	81·73	·689	45·09	39·76	53·7	10.59	8·28
Resolven	9·53	58·66	82·354	·712	40·39	38·19	35·0	10·44	4·71
Anthracite, Jones and Co.	9·46	58·25	85·786	·679	47·26	38·45	68·5	9·7	9·58
Ward's Fiery Vein	9·4	57·433	83·85	·685	46·	39·	46·5	10·6	7·44
Llangennech	8·86	56·93	81·85	·695	43·76	39·34	53·5	9·2	11·04
Three-quarter Rock Vein	8·84	56·388	83·60	·674	48·26	39·72	52·7	..	7·36
Graigola.	9·35	60·166	81·107	·742	34·8	37·23	49·3	9·66	9·27
Lydney (Forest of Dean)	8 52	54·444	80·046	·68	47·02	41·24	55·0	8·98	4·06
Pentrepoeth	8·72	57 72	81·73	·705	40·17	38·80	46·5	8·98	10·47
Cwm Ffrood Rock Vein	8·70	55·277	78·299	·706	41·648	40·52	72·5	9·35	7·8
Cwm Nanty-Gros	8·42	56·0	79·859	·701	42·60	40·00	55·7	8·82	5·44
Wylam's Patent Fuel	8·92	65·08	68·629	·948	5·45	34·41	70·0	9·74	7·27
Grangemouth	7·4	54·25	80·48	·674	48·35	40·13	69·7	7·91	5·26
Broomhill	7·3	52·5	77·988	·673	48·55	42·67	65·7	7·66	3·23

SECTION II.—On the EVAPORATING POWERS of COAL.

By Mr. J. ARTHUR PHILLIPS.

PONTYPOOL COALS.

I hereby certify that the four casks, marked Nos. 120, 121, 122, 123, contain a fair sample of Morrison's Pontypool Rock Vein Coals, which were mined specially for the service of the "Admiralty Coals Investigation."

(Signed) RICHARD MORRISON, *Proprietor.*

This colliery is situated near Pontypool, in the county of Monmouth, at the distance of about 10 miles from the shipping port, from whence the coals are exported to France, Spain, Portugal, the Mediterranean, South America, Brazils, and the West Indies. The current price is 9*s.* 6*d.* per ton.

The seam is very regular, and 8 feet in thickness. The coal is worked by level, at a depth

of about 150 yards from the surface. The subjacent and overlying strata being shale, which together with the seam itself, has an inclination of 3½ inches in the yard towards the west.

The sample of this coal which was sent up for trial, was hard and brilliant, with lines of fracture parallel to the bedding, and appeared to be considerably mixed with shale, which formed layers, very distinctly visible, parallel to the planes of deposition. This coal also contains a rather large amount of iron pyrites, which appeared to be pretty regularly disseminated throughout the mass.

It was remarked, during the experiments, that the fire lighted easily, and got the steam up rapidly, but that considerable quantities of smoke were evolved during the whole time of experiment.

This coal cokes slightly on the dead-plate, and the fire requires constant attention.

PONTYPOOL ROCK VEIN.

——	July 7, 1st day.	July 8th, 2nd day.	July 9th, 3rd day.
Fire lighted	5h. 40m.	8h.	8h. 15m.
Steam up	6h.	8h. 20m.	8h. 25m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	204°	209°	209°
Temperature of Water in Tanks	73°	68°	70°
Barometer	29·9 in.	29·98 in.	30·15 in.
Extremes of external Thermometer	64°—73°	56°—70°	62°—73°
Extremes of internal Thermometer	72°—74°	68°—72°	56°—71°
Dew-point	..	..	..
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	304 lbs.	252 lbs.	242 lbs.
Weight of Ashes left	9 lbs.	8 lbs.	15 lbs.
Per centage of combustible matter in Ashes	1·23	17·06	10·22
Weight of Cinder left	14 lbs.	30 lbs.	20 lbs.
Per centage of combustible matter in Cinder	23·27	75·74	86·59
Weight of Clinker in Cinder	4 lbs.	1·2 lbs.	..
Average Weight of Soot in flues	0·6 lbs.	0·6 lbs.	0·6 lbs.
Per centage of combustible matter in Soot	76·0	..	..
Weight of Water evaporated	2205 lbs.	1616 lbs.	1469 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·32 lbs.	7·25 lbs.	6·84 lbs.
Weight of Coals per hour for 1 square foot of grate surface	7·6 lbs.	6·3 lbs.	6·03 lbs.
Duration of Experiment	8h. 5m.	8h. 10m.	8h.
Specific gravity of Coal	1·32	..	..
Mean weight of cubic foot of Coal	55·7 lbs.	..	..
Economic weight or space occupied by 1 ton	40·216 c. f.	..	..
Cohesive power of Coal	57·5	..	..

Note.—Final temperature on fourth morning, 209°.

BEDWAS COAL.

I hereby certify that the three casks, marked Bedwas Vein Coals, contain a fair sample of the said Bedwas coals, which were mined specially for the service of the "Admiralty Coals Investigation."

(Signed) JOSEPH JONES, *Proprietor.*

This coal is mined in the parish of Bedwas, county of Monmouth, and is situated at about 10½ miles from the shipping port. The principal markets for these coals are Spain, Portugal, different ports of the Mediterranean, and in England.

The colliery was opened about eighteen months since, and appears to improve as the workings advance. The coals are at present extracted from a depth of about 30 yards, by means of a steam-engine. The thickness of the seam is 2 feet 8 inches, and the subjacent strata hard fire-clay; it is overlaid by a stratum of rock, which varies from 15 to 20 yards in thickness.

The seam has an inclination of from 4 to 5 inches in the yard towards the south.

The current price of this coal is 9*s.* 6*d.* per ton; and the character given of it by the proprietor is, "Large, hard, and free burning; free from sulphur and earthy matters, and much liked for steam purposes."

The specimen of these coals on which the experiments were made was firm and brilliant, with a cubical fracture; it contains iron pyrites, but in smaller quantities than the last.

It was remarked during the progress of these experiments, that this coal produced but little smoke, and burned freely, with the formation of but little clinker. It also ignites easily, and gets up the steam rapidly.

BEDWAS COAL.

—	August 2, 1st day.	August 3, 2nd day.	August 4, 3rd day.
Fire lighted	8h.	8h. 50m.	8h. 15m.
Steam up	8h. 50m.	9h.	8h. 33m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	168°	21°	212°
Temperature of Water in Tanks	74°	73°	69°
Barometer	30·0 in.	30·10 in.	29·9 in.
Extremes of external Thermometer	70°—82°	74°—50	75°—88°
Extremes of internal Thermometer	70°—79°	70°—75°	69°—75°
Dew-point	55°	46°	54°
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	43 lbs.	350 lbs.	390 lbs.
Weight of Ashes left	6 lbs.	6 lbs.	6 lbs.
Per centage of combustible matter in Ashes	38·53	33·84	20·79
Weight of Cinder left	11 lbs.	7 lbs.	8 lbs.
Per centage of combustible matter in Cinder	60·74	49·44	49·61
Weight of Clinker in Cinder	5·6 lbs.	2·3 lbs.	5·3 lbs.
Average weight of Soot in Flues	..	..	..
Per centage of combustible matter in Soot	..	..	..
Weight of Water evaporated	3620 lbs.	3200 lbs.	3420 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·0 lbs.	10·4 lbs.	9·98 lbs.
Weight of Coals per hour for 1 square foot of grate service	10·87 lbs.	8·75 lbs.	9·75 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·32	..	..
Mean Weight of cubic foot of Coal	50·5 lbs.	..	..
Economic weight or space occupied by 1 ton	44·32 c.f.	..	..
Cohesive power of Coal	54	..	..

Note.—Final temperature on fourth morning 212°.

PORTHMAWR ROCK VEIN COAL.

I hereby certify that the two casks, marked P M C C°, contain a fair sample of the Porthmawr Rock Vein coals, which were mined specially for the service of the "Admiralty Coals Investigation."—REIGNAULD BLEWETT, *Proprietor*.

The Porthmawr colliery is situated at a distance of about eight miles from Newport, Monmouthshire, and the coals are shipped from that port to nearly all parts of the world: its current price is from 9*s*. to 9*s*. 6*d*. per ton. They are said by the proprietor to be "excellent for steam purposes, and the manufacture of iron in all its stages."

The thickness of the seam varies from 5 to 6 feet, and is generally tolerably regular.

The coals are obtained by means of a level or horizontal gallery. The subjacent, like the overlying strata, is composed of rock and shale, which have an inclination of about six feet in the yard from N.E. to S.W.

The sample of this coal on which the experiments were made was very irregular in its cleavage, and appeared to be mixed with a considerable quantity of shale, which was disseminated in the coal, without regard to stratification. During the experiments, and throughout their continuance, a large amount of smoke was evolved. The fire, however, lighted easily, burned freely, and got the steam up rapidly; but considerable quantities of ash remained at the close of each experiment.

PORTHMAWR ROCK VEIN.

—	August 25, 1st day.	August 27, 2nd day.	August 28, 3rd day.
Fire lighted	8h. 15m.	10h. 15m.	7h.
Steam up	8h. 55m.	10h. 50m.	7h.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	167°	204°	207°
Temperature of Water in Tanks	65°	72°	72°
Barometer	30·15 in.	30·20 in.	30·12 in.
Extremes of external Thermometer	62°—70°	68°—75°	66°—76°
Extremes of internal Thermometer	62°—68°	70°—75°	68°—76°
Dew-point	46°	55°	52°
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	451 lbs.	248 lbs.	422 lbs.
Weight of Ashes left	21 lbs.	16 lbs.	18 lbs.
Per centage of combustible matter in Ashes	45·21	25·42	28·85
Weight of Cinder left	13·5 lbs.	11 lbs.	12 lbs.
Per centage of combustible matter in Cinder	40·61	21·98	29·93
Weight of Clinker in Cinder	6·5 lbs.	2 lbs.	5 lbs.
Average weight of Soot in Flues	1·3 lbs.	1·3 lbs.	1·3 lbs.
Per centage of combustible matter in Soot	83·34	..	..
Weight of Water evaporated	3090 lbs.	1750 lbs.	27·00 lbs.

Portmawr Rock Vein—*continued.*

	August 25, 1st day.	August 27, 2nd day.	August 28, 3rd day.
Weight of Water evaporated from 212° by 1 lb. of Coal	7·26 lbs.	8·05 lbs.	7·27 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11·27 lbs.	6·20 lbs.	10·55 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·39	..	..
Mean Weight of cubic foot of Coal	53·3 lbs.	..	..
Economic weight or space occupied by 1 ton	42·02 c. f.	..	..
Cohesive power of Coal	62	..	..

Note.—Final temperature on fourth morning 207°.

Warlich's Patent Fuel.

I hereby certify that the 362 bricks of Warlich's Patent Fuel, weighing two tons, which were made specially for the service of the "Admiralty Coals Investigation," are a fair sample.—T. C. Warlich, *Proprietor.*

This fuel is sold in bricks which have the following dimensions: length 9 inches, breadth 6½ inches, thickness 5 inches, which would give 252·5 inches as the cubic contents of each block; but on taking the mean of 40 blocks they were found to average only 0·177 of a cubic foot. The economic weight of a cubic foot is 69·05 lbs.

This fuel is manufactured from the Resolven coal dust, which is bought at 3*s.* per ton for this purpose. This dust on arriving in the port of London is generally very wet, and occupies when converted into fuel about 30 cubic feet to the ton.

The specimen experimented on was remarkably dense and well made, being almost as solid and difficult to break as a common brick.

It was observed during the experiments that it gives off but little smoke in burning, and that the little evolved is of a greyish colour. It, however, takes considerable time to light, and consequently does not get up the steam so rapidly as some kinds of free-burning coals.

Experience also proves that this fuel burns best when broken into fragments of about six ounces in weight, otherwise it has a tendency to cake on the bars and choke the draught.

Warlich's Patent Fuel.

	August 11, 1st day.	August 12, 2nd day.	August 13, 3rd day.
Fire lighted	8h. 45m.	9hrs.	9hrs.
Steam up	9h. 30m.	9h. 50m.	9h. 25m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	184°	212°	212°
Temperature of Water in Tanks	70°	74°	73°
Barometer	30·19 in.	30·25 in.	30·29 in.
Extremes of external Thermometer	60°—75°	63°—85°	55°—76°
Extremes of internal Thermometer	69°—75°	74°—80°	74°—80°
Dew-point	56°	68°	55°
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	441 lbs.	247 lbs.	371 lbs.
Weight of Ashes left	6 lbs.	14 lbs.	11 lbs.
Per centage of combustible matter in Ashes	25·43	35·68	15·68
Weight of Cinder left	8 lbs.	8 lbs.	6 lbs.
Per centage of combustible matter in Cinder	61·76	59·0	77·93
Weight of Clinker in Cinder	7 lbs.	2 lbs.	5 lbs.
Average weight of Soot in Flues	..	..	..
Per centage of combustible matter in Soot	..	..	..
Weight of Water evaporated	3860 lbs.	2220 lbs.	3460 lbs.
Weight of Water evaporated from 212° by 1 lb. of coals	10·32 lbs.	10·11 lbs.	10·62 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11·02 lbs.	6·17 lbs.	9·27 lbs.
Duration of Experiment	8hrs.	8hrs.	8hrs.
Specific gravity of Coal	1·15	..	..
Mean weight of Cubic foot of Coal	69·05 lbs.	..	..
Economic weight or space occupied by 1 ton	32·44 c.f.	..	..
Cohesive power of Coal	..	..	..

Note.—Final temperature on fourth morning 212°

Ebbw Vale Coal.

I hereby certify that the four casks marked E. V. contain a fair sample of the Ebbw Vale Four-feet Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—Signed by the Ebbw Vale Company.

This is generally known by the name of the Ebbw Vale Four-feet Steam Coals, and is raised at the Ebbw Vale iron works, 21 miles from Newport, where it is shipped. The principal

markets are the Mediterranean, the West Indies, and the Brazils. The present price is 10*s.* per ton.

The proprietors recommend it very strongly as "containing little sulphur," and represent it as being "much in demand for marine and other steam purposes." The mine is from 400 to 500 feet in depth, and the seam from which the coal is raised varies from 3 feet 6 inches to 4 feet 6 inches in thickness, and has an inclination of 1 in 12 towards the south.

The subjacent and overlying strata are of sandstone. The sample mined for the service of the investigation is excessively brilliant, with a cubical fracture, but rather friable, and contains little iron pyrites.

It was remarked during the experiments that they lighted easily, and got up the steam quickly, yielding a fine clear fire. They cake on the bars, but produce very little clinker, and an extremely small quantity of red ash, which is almost totally consumed when again thrown on the fire. They were also found to evolve a greyish-black smoke in rather considerable quantity, especially after stirring the fire, and from their bituminous nature require frequent stoking.

It may also be remarked that they were tried for the purpose of forging iron, and found to answer extremely well.

EBBW VALE.

	September 6, 1st day.	September 7, 2nd day.	September 9, 3rd day.
Fire lighted	9hrs.	9h. 15m.	10h. 25m.
Steam up	9h. 45m.	9h. 50m.	11h. 15m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	172°	202°	190°
Temperature of Water in Tanks	55°	63°	59°
Barometer	29·95 in.	30·02 in.	30·15 in.
Extremes of external Thermometer	40°—57°	54°—60°	51°—65°
Extremes of internal Thermometer	57°—69°	60°—65°	66°—71°
Dew-point	45°	..	..
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	445 lbs.	319 lbs.	320 lbs.
Weight of Ashes left	7 lbs.	13 lbs.	8 lbs.
Per centage of combustible matter in Ashes	92·0	94·2	83·9
Weight of Cinders left	8·8 lbs.	10·0 lbs.	9 lbs.
Per centage of combustible matter in Cinder	97·5	14·1	74·6
Weight of Clinker in Cinder	1·3 lbs.	None.	3·2 lbs.
Average weight of Soot in Flues	7 lbs.	7 lbs.	7 lbs.
Per centage of combustible matter in Soot	57·9	..	..
Weight of Water evaporated	3620 lbs.	2700 lbs.	3120 lbs
Weight of Water evaporated from 112° by 1 lb. of Coal	10 lbs.	9·44 lbs.	11·20 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11·12 lbs.	7·97 lbs.	8·1 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·275	..	..
Mean weight of cubic foot of Coal	53·33 lbs.	..	..
Economic weight or space occupied by 1 ton	42·26 c. f.	..	..
Cohesive power of Coal	45·0	..	..

Note.—Final temperature on fourth morning 190°.

FORDEL SPLINT COAL.

I hereby certify, that the two casks, marked F, S, C, contain a fair sample of the Fordel Splint Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—(Signed) ALEXANDER LYELL, *Agent for George Mercer Henderson, Proprietor.*

The colliery from which this coal is extracted is situated in the parish of Dalgety, in the county of Fife, and is from five to six miles from the shipping port, where its current price is 9*s.* per ton. It is raised from what is called the Splint Seam, at a depth of from 50 to 80 fathoms from the surface.

This vein is generally from 4 to 4½ feet in thickness, and has an inclination of from 16° to 20° towards the north-east. It is worked by stoop and round, or Shropshire method, and is generally pretty regular. The proprietor describes this coal as "hard, bituminous, and lively in burning."

The specimen which came into our hands was lameller in structure, with oblique cross partings; it consisted of very brilliant layers, interspersed with less shining laminæ which resemble mineralized charcoal. This coal is extremely hard, but, when broken, divides into rhombic fragments. Spots of pyrites sometimes occur, but not in any considerable quantity.

During the experiments, it was observed that they light up easily, and give a strong flame. They also require but little stoking, it being only necessary to push the coked coals forward from the dead-plate, and replace them by fresh coals, in order to maintain a good clear fire: they were also found to produce a considerable quantity of greyish smoke, but leave little ash or clinker.

FORDEL SPLINT.

	September 15, 1st day.	September 17, 2nd day.	September 18, 3rd day.
Fire lighted	8h. 45m.	9h. 40m.	8h. 30m.
Steam up	10h.	10h. 10m.	8h. 45m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	118°	203°	207°
Temperature of Water in Tanks	63°	62°	62°
Barometer	29·95 in.	29·95 in.	30·15 in.
Extremes of external Thermometer	52°—62°	45°—54°	45°—62°
Extremes of internal Thermometer	61°—66°	64°—70°	63°—66°
Dew-point	54°	55°	53°
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	597 lbs.	413 lbs.	465 lbs.
Weight of Ashes left	5 lbs.	7 lbs.	8 lbs.
Per centage of combustible matter in Ashes	45·9	68·7	64·8
Weight of Cinder left	4·5 lbs.	7 lbs.	4·5 lbs.
Per centage of combustible matter in Cinder	77·78	59·40	68·8
Weight of Clinker in Cinder	1·5 lbs.	None.	0·3 lbs.
Average weight of Soot in Flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in Soot	70·0	..	..
Weight of Water evaporated	3625 lbs.	2870 lbs.	3060 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	7·78 lbs.	8·04 lbs.	6·87 lbs.
Weight of Coals per hour for 1 square foot of grate surface	14·92 lbs.	10·32 lbs.	11·62 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·25	..	..
Mean weight of cubic foot of Coal	55·0 lbs.	..	..
Economic weight or space occupied by 1 ton	40·72 c. f.	..	..
Cohesive power of Coal	63·0	..	..

Note.—Final temperature on fourth morning 150°.

COLESHILL COAL.

I hereby certify, that the 85 tons of coals, shipped per schooner "Brothers," addressed to the Superintendents of Her Majesty's Dockyard, Woolwich, are a fair sample of the Coleshill Coal Company's coals, which were mined specially for the service of the "Admiralty Coals Investigation."—(Signed) WILLIAM MAXWELL, *Agent for the Coleshill Company.*

This pit is situated at the distance of about one mile from the village of Bagilt, on the river Dee, from whence the coal is shipped for different parts of Great Britain, and more particularly for the Irish and Welsh coasts. The current price is 8*s.* 6*d.* per ton, and it is described by the agent as "free burning, strongly bituminous, and leaving very little of a white ash." He further adds, "This coal is extensively used by the Steam Navigation Company of Liverpool, as also by the various lead-smelting establishments on the river Dee, and is highly approved of."

The coal is extracted from a depth of 80 yards from the surface, and the seam, which is 5 feet 9 inches in thickness, is generally pretty regular. It has an easterly dip of 1 in 5, and is worked by stalls 7 yards in width. The overlying and adjacent strata are rock and shale.

The specimen of this coal, which was sent us for trial from Her Majesty's Dockyard at Woolwich, was in rather small fragments, and appears to crumble easily into rhombic fragments, which are apt to fall through the fire-bars. It, however, lights easily and burns freely, producing a considerable quantity of black smoke, which escapes during the whole time of combustion, but more particularly immediately after charging the grate. After the experiment, large quantities of ash mixed with shale and scoria remained.

Note.—It was also observed that the coals did not appear to be carefully picked, as large masses of black and blue shale were observed to be mixed with them.

COLESHILL COAL.

	October 7, 1st day.	October 8, 2nd day.	October 9, 3rd day.
Fire lighted	9h. 15m.	9h. 30m.	9h. 30m.
Steam up	9h. 45m.	9h. 45m.	9h. 50m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	200°	209°	205°
Temperature of Water in Tanks	60°	56°	58°
Barometer	29·67 in.	30·0 in.	30·05 in.
Extremes of external Thermometer	43°—57°	50°—63°	51°—62°
Extremes of internal Thermometer	61°—66°	63°—67°	65°—68°
Dew-point	57°	..	58°
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	405 lbs.	283 lbs.	332 lbs.
Weight of Ashes left	9 lbs.	9 lbs.	11 lbs.
Per centage of combustible matter in Ashes	35·1	44·9	26·0
Weight of Cinder left	10 lbs.	10 lbs.	7 lbs.
Per centage of combustible matter in Cinder	5·82	57·2	63·6

Coleshill Coal—*continued.*

—	October 7, 1st day.	October 8, 2nd day.	October 9, 3rd day.
Weight of Clinker in Cinder	8 lbs.	4 lbs.	6 lbs.
Average weight of Soot in Flues	1·5 lbs.	1·5 lbs.	1·5 lbs.
Per centage of combustible matter in Soot	71·5	..	..
Weight of Water evaporated	2650 lbs.	2160 lbs.	2270 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	7·67 lbs.	8·67 lbs.	7·68 lbs.
Weight of Coals per hour for 1 square foot of grate surface	11·57 lbs.	8·08 lbs.	11·06 lbs.
Duration of Experiment	7 hrs.	7 hrs.	6 hrs.
Specific gravity of Coal	1·29	..	..
Mean weight of cubic foot of Coal	53 lbs.	..	..
Economic weight or space occupied by 1 ton	42·26 c. f.	..	..
Cohesive power of Coal	62·0	..	..

Note.—Final temperature on fourth month, 190°.

SLIEVERDAGH COAL.

I hereby certify, that the three casks and one box, marked Coals from the Slieverdagh Collieries, contain a fair sample of the Slieverdagh coals from the county of Tipperary, which were mined specially for the service of the "Admiralty Coals Investigation."—(Signed) WILLIAM BULLEN, *Part Proprietor and Agent.*

This coal field is situated in the barony of Slieverdagh, in the county of Tipperary, Ireland. It lies between the towns of Cullen and Willingford, being seven miles distant from the former, and about three from the latter place. The nearest shipping port is Carrick-on-Suir; but as soon as the railways are completed, the communication will be opened to the Shannon and Cork harbour. The thickness of the vein is 3 feet, and the coals employed in the experiments were extracted from a depth of about 25 yards from the surface, by means of a whim, though a tunnel is now in progress, in which a tramroad is to be laid, so as to enable the coal to be removed directly from the seam by means of horses. The vein itself has an inclination of 1 in 5, and is situated in soft slate and sandstone, both easily worked. This coal is at present chiefly sold in the surrounding country and neighbouring towns, and fetches at the pit's mouth from 1*l.* to 1*l.* 5*s.* per ton.

The specimen of this coal which came into our hands was highly anthracitic, and it was therefore determined to make the experiment of three times the usual length, in order to avoid the inconvenience and loss of heat which would have attended the frequent lighting and extinction of a coal which, though difficult to light, would, when once burning, take several hours to become extinct.

In order to light the fire, 50 lbs. of the Coleshill coals were employed, for which allowance was of course made in the calculations. It was observed during the experiments that this coal requires a strong draught, and that the fire requires to be well supplied with fuel, which should be previously heated on the dead-plate to prevent decrepitation. When these precautions were attended to, a beautifully clear fire, without smoke, was obtained, which left no soot in the flues. The fire took seven hours to become extinguished at the close of the experiment.

SLIEVERDAGH.

—	October 13.
Fire lighted	8h. 40m.
Steam up	10h. 30m.
Weight of Water used	10 lbs.
Initial Temperature of Water in Boiler	150°
Temperature of Water in Tanks	60°
Barometer	30·05 in.
Extremes of external Thermometer	40°—60°
Extremes of internal Thermometer	64°—70°
Dew-point	53°
Area of Damper open	112 in.
Weight of Coals consumed	1249 lbs.
Weight of Ashes left	21 lbs.
Per centage of combustible matter in Ashes	67·9
Weight of Cinder left	59 lbs.
Weight of Clinker in Cinder	10 lbs.
Per centage of combustible matter in Cinder	91·5
Average weight of Soot in Flues	None.
Per centage of combustible matter in Soot	..
Weight of Water evaporated	10·980 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	9·85 lbs.
Weight of Coals per hour for 1 square foot of grate surface	9·60 lbs.
Duration of Experiment	26 hrs.
Specific gravity of Coal	1·59
Mean weight of cubic foot of Coal	62·8 lbs.
Economic weight or space occupied by 1 ton	35·66 c. f.
Cohesive power of Coal	74·

Note.—Final temperature on fourth morning 195°.

Wallsend Elgin Coals.

I hereby certify, that the two casks marked E, W, contain a fair sample of the Wallsend Elgin Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—(Signed) Robert Menzies, *Agent for the Trustees of the late Earl of Elgin.*

This coal is raised in the lands of Clume and Baldridge, in the parish of Dunfermline, in the county of Fife, at a distance of five miles from the shipping port. Its current price is 9s. per ton on board. It is principally used for steam navigation and steam purposes in general. The seam from which it is extracted is 4½ feet in thickness, and is generally very regular, with an average dip of 1 in 7 towards the north. The subjacent and overlying strata consist of alternate layers of sandstone and coal-slate.

This coal is at present extracted at the depth of 105 fathoms, and is described as "a caking splint of cubical texture, burning freely with a strong flame."

This coal exactly resembles in appearance the Fordel Splint: it was observed during the experiments, that it lighted easily, and gave a good fire, which required but little stoking; it has, however, the disadvantage of giving off considerable quantities of a greyish smoke during the whole time of its burning.

Wallsend Elgin.

—	September 28, 1st day.	September 29, 2nd day.	September 30, 3rd day.
Fire lighted	9hrs.	9hrs.	9h. 15m.
Steam up	9h. 20m.	9h. 25m.	9h. 55m.
Weight of Wood used	10 lbs.	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	204°	210°	195°
Temperature of Water in Tanks	58°	60°	61°
Barometer	30·38 in.	30·29 in.	30·27 in.
Extremes of external Thermometer	40°—59°	45°—60°	45°—59°
Extremes of internal Thermometer	60°—64°	64°—66°	64°—67°
Dew-point	53°	51°	50°
Area of Damper open	112 in.	56 in.	84 in.
Weight of Coals consumed	509 lbs.	275 lbs.	461 lbs.
Weight of Ashes left	7 lbs.	5 lbs.	8 lbs.
Per centage of combustible matter in Ashes	58·8	53·6	40·0
Weight of Cinder left	10·5 lbs.	9 lbs.	6 lbs.
Per centage of combustible matter in Cinder	60·8	58·9	72·1
Weight of Clinker in Cinder	2·3 lbs.	0·8 lbs.	5 lbs.
Average weight of Soot in Flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in Soot	58·2	..	..
Weight of Water evaporated	3640 lbs.	2220 lbs.	3290 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	8·33 lbs.	8·85 lbs.	8·21 lbs.
Weight of Coals per hour for 1 square foot of grate surface	12·72 lbs.	6·87 lbs.	11·52 lbs.
Duration of Experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of Coal	1·26	..	..
Mean weight of cubic foot of Coal	54·6 lbs.	..	..
Economic weight or space occupied by 1 ton	41·02 c. f.	..	..
Cohesive power of Coal	64	..	..

Note.—Note temperature on fourth morning 195°.

Dalkeith Coronation Seam. Dalkeith Jewel Seam.

The experiments on these two coals were repeated, from the circumstance of their having been tried in the first instance when the brickwork of the boiler was still damp, which circumstance must necessarily have interfered with the results obtained.

During our experiments it was observed of both these coals, that they lighted easily and burned freely without the production of much smoke. They also required little stoking, and left but an inconsiderable quantity of incombustible matter.

Dalkeith.

—	September 10, Coronation Seam.	September 11, Jewel Seam.
Fire lighted	8h. 30m.	11hrs.
Steam up	9hrs.	11h. 40m.
Weight of Wood used	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	180°	193°
Temperature of Water in Tanks	65°	61°
Barometer	30—13 in.	30—15 in.
Extremes of external Thermometer	49°—66°	54°—61°
Extremes of internal Thermometer	70°—72°	68°—70°
Dew-point	49°	56°
Area of Damper open	84 in.	84 in.
Weight of Coals consumed	288 lbs.	301 lbs.

Dalkeith—*continued.*

—	September 10, Coronation Seam.	September 11, Jewel Seam.
Weight of ashes left	9 lbs.	6 lbs.
Per centage of combustible matter in Ashes	18·8	20·5
Weight of Cinder left	7·2 lbs.	5 lbs.
Per centage of combustible matter in Cinder	42·	24·8
Weight of Clinker in Cinder	8 lbs.	8 lbs.
Average weight of Soot in flues	..	..
Per centage of combustible matter in Soot	..	..
Weight of Water evaporated	1900 lbs.	1880 lbs.
Weight of Water evaporated from 212° by 1 lb of Coal	7·71 lbs.	7·08 lbs.
Weight of Coals per hour for 1 square foot of grate surface	960 lbs.	10·30 lbs.
Duration of Experiment	6 hrs.	6 hrs.
Specific gravity of Coal	1·316	1·277
Mean weight of cubic foot of Coal	55·16 lbs.	49·8 lbs.
Economic weight, or space occupied by 1 ton	43·36 c. f.	44·98 c. f.
Cohesive power of Coal	88·2	85·7

Note.—Final temperature on third morning 180°.

Bell's Fuel.

No certificate has been received with this fuel.

This fuel is manufactured at Port Talbot, near Taibach, Wales, and is formed into blocks, having the following dimensions: 9 × 6 × 5, which would give 270 cubic inches, or ·015 cubic foot, as the contents of each brick. The economic weight of a cubic foot, as deduced from the measurement of a pile, having the following dimensions: 24 × 21 × 18 inches, was found to be 65·3 lb.

In appearance this fuel resembled the specimen sent up for trial by Wylam and Co., except that the bricks were smaller and, perhaps, rather more irregular in their texture, some having a compact resinous structure, whilst others easily crumbled under the blow of a hammer.

It was observed that this fuel produced considerable quantities of dense black smoke on lighting the fire, which ceased to be evolved as the experiments progressed. This fuel was found highly bituminous, and to soften slightly even at the temperature of 212° Faht., while at higher temperatures it melted readily, and filaments were frequently observed to run through the fire-bars during the experiments. At the termination of the experiments, considerable quantities of ash and clinker remained, and during their progress, the fire required very great attention and frequent stoking, in order to prevent the choking of the grate from the swelling and melting of the fuel.

Bell's Patent Fuel.

—	December 8, 1st day.	December 9, 2nd day.
Fire lighted	9hrs.	10 hrs.
Steam up	9h. 50m.	10h. 25m.
Weight of Wood used	10 lbs.	10 lbs.
Initial Temperature of Water in Boiler	198°	204°
Temperature of Water in Tanks	48°	50°
Barometer	..	29·86 in.
Extremes of external Thermometer	32°—56°	49°—56°
Extremes of internal Thermometer	48°—56°	60°—67°
Dew-point	40°	54°
Area of Damper open	112 in.	84 in.
Weight of Coals consumed	584 lbs.	446 lbs.
Weight of Ashes left	10 lbs.	8 lbs.
Per centage of combustible matter in Ashes	40·2	18·2
Weight of Cinder left	6 lbs.	5 lbs.
Per centage of combustible matter in Cinder	93·5	84·3
Weight of Clinker in Cinder	19 lbs.	16 lbs.
Average weight of Soot in flues	..	..
Per centage of combustible matter in Soot	..	..
Weight of Water evaporated	3660 lbs.	3740 lbs.
Weight of Water evaporated from 212° by 1 lb. of Coal	7·33 lbs.	9·74 lbs.
Weight of Coals per hour for 1 square foot of grate surface	14·6 lbs.	15·15 lbs.
Duration of Experiment	8 hrs.	8 hrs.
Specific gravity of Coal	1·14	..
Mean weight of cubic foot of Coal	65·3 lbs.	..
Economic weight or space occupied by 1 ton	34·30 c. f.	..
Cohesive power of Coal	..	..

Note.—Final temperature on fourth morning 204°.

SUMMARY.

—	Evaporating power, or number of pounds of Water evaporated from 212° by 1 lb of Coal (economic).	Weight of 1 cubic foot of the Coal as used for fuel. — Lbs.	Weight of 1 cubic foot as calculated from the density. — Lbs.	Ratio of B. to C. or of the economical to the theoretical weight.	Difference per cent. between theoretical and economical weights.	Space occupied by 1 ton in cubic feet (economic weight).	Results of experiments on cohesive power of Coals (per centage of large Coals.)	Evaporating power of the Coal, after deducting for the combustible matter in the residue.	Per centage of residue in Coal. — Mean.	Wei of W evapo fro 212 1 cu foo
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K
Pontypool	7·47	55·7	82·35	·6763	47·845	40·216	57·5	8·04	12·63	416
Bedwas	9·79	50·5	82·6	·6113	63·565	44·32	54·0	9·99	4·79	494
Porthmawr	7·53	53·3	86·722	·614	62·7	42·02	62·0	7·75	9·54	401
Warlich's Patent Fuel .	10·36	69·05	72·248	·955	4·49	32·44	..	10·60	6.79	715
Ebbw Vale	10·21	53·3	78·81	·676	45·98	42·26	45·0	7·10	5·87	544
Dalkeith Jewel Seam. .	7·08	49·8	79·672	·625	59·984	44·98	85·7	7·10	3·92	352
,, Coronation Seam	7·71	51·66	78·611	·657	52·17	43·36	88·2	78·6	5·9	398
Fordel Splint	7·56	55·0	78·611	·699	42·92	40·72	63·	7·69	2·86	415
Wallsend Elgin . . .	8·46	54·6	78·611	·694	43·78	41·02	64·	8·67	4·73	460
Slieverdagh	9·85	62·8	99·57	·630	58·55	35·66	74·	10·49	7·25	618
Coleshill	8·0	53·0	80·483	·658	51·85	42·26	62·	8·34	7·78	424
Bell's Patent Fuel . .	8·53	65·3	71·124	·918	8·91	34·30	..	8·65	6·70	577

COMPARISON between the Effects produced by the BOILERS at PAR CONSOLS MINE, and those obtained from that employed for the purposes of the foregoing Investigation.

A large amount of facts relative to the evaporative powers of various coals having been amassed during the progress of this inquiry, it was thought desirable to ascertain how nearly these results approach the maximum duty obtained from Cornish boilers, and thus furnish a means of comparison between the apparatus employed for the purposes of this investigation, and larger boilers, of similar construction, as used for practical purposes.

Experiments have at different times been made, in order to ascertain, with accuracy, the quantity of water which can, under the most favourable circumstances, be evaporated from a given temperature, by the combustion of one pound of coal.

No very decisive results appear, however, to have been arrived at; as, on consulting those of the different experimentalists, considerable differences will be observed. Smeaton, who seems to have been the first to pay serious attention to this subject, found, in the year 1772, that one pound of Newcastle coal evaporated 7·88 lbs. of water from 212°. Watt, who turned his attention to this subject in the year 1788, arrived at the conclusion that 8·62 lbs. of water might be evaporated from the temperature of 212° by one pound of the coal employed in his experiments; whilst Mr. Wicksteed, in the year 1840, found that one pound of Merthyr coal could be made to evaporate 9·493 lbs. of water from the temperature of 80° Faht., which is equal to the evaporation of 10·746 lbs. from the temperature of 212°.

Some experiments were also made, about this time, on the boilers of Loam's engine, at the United Mines in Cornwall, to which was adapted an apparatus which correctly measured the quantity of water injected into the boilers. The experiment was continued six months; and during that time, it was found that 234,210 cubic feet of water, at the temperature of 102° Faht., had been pumped into the boiler, and that 700 tons of coal had been consumed in its evaporation; thus showing, that 15 cubic feet of water, at 102°, had been evaporated for each 100 lbs. of coals used; or that each pound of coals consumed had evaporated 10·29 lbs. of water from the temperature of 212° Faht.

It will be observed, that these results not only differ considerably from each other, but also that no means was employed for the purpose of ascertaining the chemical composition of the various coals used, which should, we conceive, form an important part of all such investigations. In order, therefore, to obviate this inconvenience, as well as to take advantage of such improvements as may have been introduced since the dates of the foregoing experiments, it was determined to make a similar inquiry into the evaporating powers of the boilers of one of the best Cornish engines of the present day. That chosen for this purpose, was the large pumping-engine at Par Consols Mine, where every facility was afforded by Mr. West, the engineer, for carrying on the experiments effectually. This engine is an 80, with a 12-foot stroke in the cylinder, and is worked by two boilers*, to which is added an arrangement, by which the feed-water is heated to near the boiling point before entering the boiler. This is effected by means of the waste heat escaping from the flues; and the apparatus consists of two wrought-iron tubes, each about 20 inches in diameter, placed above each other, and parallel to the axis of the boilers, in the brickwork of which they are inclosed. The feed-water is pumped into the upper tube by means of the usual arrangement, and then descends through a pipe into the lower one, from whence it passes into the boiler itself. Both these tubes are exposed in their whole length to the action of the heated gases coming from the fires, which, after having made the circuit of the boilers, pass round the warming tubes before arriving at the base of the

* The boilers on which this experiment was made are each 32 ft. in length and 6 ft. 3 in. in diameter. Each boiler presents a heating surface of 950 sq. ft., and the warming apparatus offers a surface of 560 sq. ft. to the action of the heated gases.

chimney; the water in the tubes is thus heated to about 212° by means of the heat absorbed from the gases passing through the flues, and of which the temperature is reduced to about 300° by the time they arrive at the base of the chimney. Our experiments were conducted in the following manner:—

It was first necessary to be enabled to measure with accuracy the quantity of water supplied to the boilers; and in order to effect this, a large cistern was placed near the air-pump, from the cistern of which it could, by a simple arrangement, be filled with water. The connecting-pipe between the feed-pump and air-pump cistern was then removed, and a pipe fitted to the feed-pump, which reached the bottom of the reservoir. The cistern was also provided with a waste-pipe, which prevented its being filled beyond a certain point; it was then filled with water and pumped out, in order to ascertain at what level the pump ceased to act. This point being decided, water was weighed into the cistern until it reached the level of the waste-pipe before mentioned, when it was found to contain 1260 lbs. It was also necessary to be enabled to stop the action of the feed-pump during the filling up of the cistern; and this was accomplished by means of a stop-cock placed in the feed-pump immediately under the stuffing-box, which, when opened, let in air and prevented the formation of a vacuum.

The measurement of the injected water was thus rendered excessively easy, as it was only necessary to count the cisterns pumped into the boilers, and open the stop-cock whilst it was being filled, in order to do so with accuracy.

The arrangements for measuring the water having been completed, the experiment was begun; and at the expiration of 46½ hours it was found that 95 cisterns of water* had passed into the boiler, and that 11·730 lbs. of coals had been consumed; or, in other words, that 11·730 lbs. of coals had been consumed in order to evaporate 119,700 lbs. of water from the temperature of 92° Faht., which gives 10·204 lbs. of water evaporated from that temperature for every pound of coal consumed. If, as in the former part of this Report, we take 212° as the standard temperature, we find that each pound of coal employed had evaporated 11,428 lbs. of water from the boiling point.

The combustible employed during this experiment consisted of a mixture of Swansea and Bury coal; but in what proportion, or from what pits, we were unable to learn. An analysis of the mixture was, however, made by my colleague, Mr. H. How, who obtained the following results:—

Carbon . .	84·19
Hydrogen . .	4·19
Oxygen . .	0·86
Nitrogen . .	0·80
Ash . . .	8·06
Sulphur . .	1·90
Total .	100·0

These coals were also found to contain 6 per cent. of water, the greater portion of which had been intentionally added, for the purpose of communicating intensity to the heat obtained during their combustion.

Having now ascertained the quantity of water evaporated by one pound of coals, as well as the composition of the coal employed, it remains to institute a comparison between the evaporative capacity of the boilers experimented on, and that employed for the purposes of this inquiry. In order to have done this, it would have been desirable to have made a comparative experiment with the same coal when consumed in the latter boiler; but as circumstances prevented this from being done, we may obtain nearly the same results by consulting the table of analyses, and selecting a coal having as nearly as possible the same composition as that in question. If we compare the following analyses, it will be found that the Mynydd Newydd coals are so similar in their composition to those used in the Cornish experiment, as to be considered practically identical:—

Analyses.

	Mynydd Newydd.	Cornish.
Carbon . .	84·26	84·19
Hydrogen . .	5·61	4·19
Ash . . .	3·26	8·06
Sulphur . .	1·21	1·90
Nitrogen . .	1·56	0·80
Oxygen . .	3·52	0·86
Total .	100·00	100·00

The practical trial made on the Mynydd Newydd coal in the experimental boiler, gave 9·52 as its evaporative value; if, then, we assume that the two coals possess equal calorific powers, the evaporative values of the two boilers will evidently be as 9·52 is to 11·42; or, in other words, the Cornish boilers will be found to possess a superiority of nearly 20 per cent. over that used for the purposes of the investigation.

Assuming, then, the economic equality of these two coals, we have only to multiply the results obtained by the various coals during our own experiments by 1·1995, in order to ascertain their several evaporative values if consumed under the Cornish boilers.

* We took care to assure ourselves, by means of the gauges, that the boiler contained the same quantity of water at the beginning and close of the experiments.

The following table has been calculated upon this assumption,* and should therefore be considered only as an approximation:—

TABLE X.

Name of Coal.	Evaporative Power, Admiralty boiler. Actual.	Evaporative Power, Cornish boiler. Theoretical.	Name of Coal.	Evaporative Power, Admiralty boiler. Actual.	Evaporative Power, Cornish boiler. Theoretical.
Mynydd Newydd . . .	9·52	11·42	Bedwas	9·79	11·74
Graigola	9·35	11·21	Ebbw Vale.	10·21	12·24
Anthracite (Jones & Aubrey)	9·46	11·34	Porthmawr.	7·53	9·03
Old Castle Fiery Vein . .	8·94	10·72	Dalkeith Jewel Seam . .	7·08	8·49
Ward's Fiery Vein . . .	9·40	11·27	,, Coronation Seam	7·71	9·24
Binea	9·94	11·92	Wallsend Elgin . . .	8·46	10·14
Llangenock	8·86	10·62	Fordel Splint	7·56	9·06
Pentripoth	8·72	10·46	Grangemouth	7·40	8·87
Pentrefellin	6·36	7·62	Coleshill	8·00	9·59
Powell's Duffryn . . .	10·149	12·17	Broomhill	7·30	8·75
Three-quarter Rock Vein .	8·84	10·60	Lydney	8·52	10·22
Cwm Frood Rock Vein .	8·70	10·43	Slievardagh (Irish) . .	9·85	11·81
Cwm Nanty-Gros . . .	8·42	10·10	Wylam's Patent Fuel . .	8·92	11·70
Resolven	9·53	11·43	Warlich's ,, . .	10·36	12·42
Pontypool	7·47	8·96	Bell's ,, . .	8·53	10·23

SECTION III.—FORMULÆ for ESTIMATING the EVAPORATIVE VALUE of FUEL. By Messrs. WILSON and KINGSBURY.

We now proceed to give an account of the formulæ employed in some of the calculations, and of some experiments on the indications of the thermometers employed in giving the temperatures of the flues; and on one or two points connected with the inquiry, which could not with propriety be incorporated in previous parts of the Report:—

I. To calculate the evaporating power of the coals.

In this investigation, several circumstances must be taken into consideration, which materially affect the relative quantities of water evaporated and coal consumed.

1. The temperature of the water in the tanks is not the same as that of the water in the boiler, and it varies during the day.

2. The temperature of the water in the boilers and in the tanks, varies with the external temperature of the air, and the circumstances under which the experiments are conducted.

3. The surface temperature of the water in the boiler is not the same as the *mean temperature* of the whole mass of water in it.

4. A considerable portion of the water exposed to the action of the fire is not converted into steam.

5. Some wood being employed in lighting the fire, its heating effect must be calculated and allowed for.

Other circumstances, slightly modifying the results, may be noticed, such as—the expansion of the water in the boiler—of that in the tanks—the expansion of the boilers and of the tanks themselves—the heat lost in raising the temperature of the air in the boiler-house—of the air, aqueous vapour, and gases passing through the fire and flues—of the iron, brick and stonework, of the setting, besides the heat absorbed in vaporizing the water (hygroscopic) existing in the coals, &c., &c.; but in a preliminary Report like the present, it has been thought useless to take these into account, and even then, in all probability, it would be valueless, while the errors of observation remain of such magnitude and importance.

The calculation of the evaporating power has been made in this way: the quantity of fuel consumed was divided into two parts, the first being the weight required to raise the whole mass of water exposed during the experiment to the action of the fire from the *mean temperature* to 212°, and the second, that required to evaporate the quantity of water taken from the tanks, already raised to 212°. Hence we, in the first place, calculated the *mean* temperature of the whole mass, that is, of the water in the boiler at its initial temperature, when mixed with the water drawn from the tanks, at its average temperature. Since the temperature of the water in the tanks varied during the day, we took several observations to get an average, which may be called t'.

Let w be the weight of water drawn from the tanks, temperature t'.
W ,, in boiler ,, ,, t''
t temperature after mixture.

$$\text{Then } t = \frac{W t'' + w t'}{W + w} - (A)$$

t'' is the mean temperature of the mass of water in the boiler, mentioned in No. 3, and was deduced from the surface temperature by means of a correction derived from experiment.

* The Mynydd Newydd coal, supposing there was no loss of heat, is capable of evaporating 14·90 lbs. of water, and the Welsh coal (used in Cornwall) 14·28 lbs.; but considering that this heat cannot all be obtained in practice, these economic values for calculation might be taken as equal without introducing any serious error.

For No. 5, we made a correction by deducting, from the weight of water evaporated, a quantity equivalent to the work done by the wood employed, the evaporating power of which was determined from data furnished by one day's experiment on the wood usually employed in lighting the fire, by means of the following investigation:—

To calculate (e) the coefficient of evaporating power of the wood, that is, the number of lbs. of water which 1lb. will evaporate from 212°.

In the actual experiment, by burning a certain weight of wood under the boiler, we raise a certain weight of water from a known temperature to the boiling point, and then evaporate a given portion of it.

Let N be the total weight of wood consumed in raising (W + w) (the sum of the weight of water in the boiler, and of that portion drawn from the tanks during the experiment), from the mean temperature t given by (A) to 212°, and also in evaporating w from 212°, we want to find the weight N′, necessary to evaporate w from 212°.

$$\text{Then } \frac{w}{N'} = e, \text{ the evaporating power.}$$

Let m be the weight of wood required to raise W + w from t to 212°, and 1000 the latent heat of steam.

n to evaporate W + w from 212°

N′ „ w „

$$\text{Then } m + N' = N.$$

$$\text{Now } \frac{l}{212 - t} = \frac{n}{m}$$

$$\text{But } \frac{n}{N'} = \frac{W + w}{w}$$

$$\therefore N' = n \frac{w}{W + w}$$

$$l (N - N') = (212 - t) n$$

$$= (212 - t) N' \left(\frac{W + w}{w}\right).$$

$$N l = N' \left\{\frac{W + w}{w} (212 - t) + l\right.$$

$$\left.\frac{N'}{w}\right\} (212 - t) (W + w) + l w$$

$$\therefore \frac{w}{N'} = \frac{(212 - t) (W + w) + l w}{N t}$$

$$= e$$

Or, introducing the value of t given by (A).

$$\frac{(l + 212 - t') w + (212 - t'') W}{N l} = e$$

Hence if q be the weight of wood employed in lighting the fire, $e q$ will be the weight of water evaporated from 212° by the wood, which must be deducted from the weight of water evaporated in calculating the work done by the coals.

To calculate the coefficient of evaporating power of the coal, or the weight of water which 1 lb will evaporate from 212°.

Let P be the total weight of coal consumed, then the work done by P will be to raise W + w of water from t to 212°, and to evaporate $w - e q$ from 212°.

Let m be the weight of coal required to raise W + w to 212° from t

p „ „ evaporate $w - e q$ from 212°

n „ „ „ W + w from 212°

$$\text{Then } \frac{w - e q}{p} = E, \text{ the evaporating power.}$$

$$\text{Now } P = m + p$$

$$\frac{212 - t}{l} = \frac{m}{n}$$

$$\text{But } \frac{p}{n} = \frac{w - e q}{W + w}$$

$$\therefore l \left(\frac{w - e q}{W + w}\right) = p \frac{212 - t}{P - p}$$

$$\frac{(W + w) (212 - t) + (w - e q) l}{P l} = \frac{w - e q}{p}$$

$$= E$$

Introducing the values from which the mean temperature t was obtained (A), we have eventually

$$\frac{(l + 212 - t')\, w + (212 - t'')\, W - l\, e\, q}{P\, l} = E$$

in which W is the weight of water in the boiler;
w ,, drawn from the tanks during the experiment;
t' the mean temperature of water in tanks;
t'' the corrected initial temperature of the water in the boiler.

Correction in the calculated evaporating power of the Coals for the combustible matter existing in the residua.

The experiments made for the purpose of determining the quantity of combustible matter in the residua show that all the coal is not usefully burned in evaporating water; hence the calculated coefficient of evaporating power is in every case somewhat too low. The following is an attempt to make an allowance for this by way of correction.

For this, which must be considered as a very rough approximation, we must assume that in whatever ratio the combustible and incombustible matters exist in the ashes, cinders, &c., that the amount of work done or of water evaporated is proportional to the quantity of combustible matter present, and also, that the same quantity of water would be evaporated by a weight of coal containing the same quantity of combustible matter as the residua under consideration.

If then Q be the weight of coal containing the same weight of combustible matter as the residua after its combustion in the furnace,

$$\frac{(l + 212 - t')\, w + (212 - t'')\, W - l\, e\, q}{(P - Q)\, l} = E', \text{ the corrected coefficient of evaporating power.}$$

Let then

w_1, w_2, w_3 be the weights of { ashes, cinders*, soot } after the experiment.

r_1, r_2, r_3 the per centage of combustible matter in them respectively,

Q the weight of coal containing the same weight of combustible matter,
r the per centage of combustible matter in the coal (as given by chemical analysis);

Then $r\, Q = r_1 w_1 + r_2 w_2 + r_3 w_3$

$$\therefore Q = \frac{r_1 w_1 + r_2 w_2 + r_3 w_3}{r}$$

For the purpose of ascertaining the heat of the gases passing along the flues, and also up the chimney after having passed over the entire heating surface of the boiler, an arrangement was made by which thermometers, graduated up to the boiling point of mercury, were inserted in the flues (H, I, K) at about one-third of their depth from the top. This was done by means of iron tubes closed at the bottom, and firmly cemented and worked into the brick setting of the boilers. In order to make the contact perfect between the iron tubes and the thermometer bulbs placed in them, that the heat might be equally diffused, some mutton suet or oil was placed in the tubes sufficient to fill three or four inches of their length. We commenced the trials making use of this arrangement, which enabled us, so far, to regulate the damper (K) in checking or increasing the draft and consequent heat of the gaseous products. Having, however, occasion to take the temperature of the gases in the chimney with a naked thermometer, we found that the heat thus shown was greater to some extent than that indicated by the thermometer inserted in the iron tube of the escape flue at the damper (K). As this was a matter that would materially affect all our thermometer observations, we at once took up one of the tubes in the side flues (I), in order to see, by comparative observations, how far this arrangement of iron tubes and oil had misled us in the estimation of the actual temperature of the flues; previously making a series of observations with the thermometers in the tubes as they were then fixed in the two side flues (H, I), to satisfy ourselves that the currents of heated gases were equal on both sides of the boiler.

The variation was found to be but small and very irregular; certainly not of sufficient importance to affect our results, which were as follows:—

Thermometer *in tube* H.		Thermometer *naked* in *flue* (I).
Observation 1	380°	530°, with usual draft (70 square inches).
,, 2	370°	400°, damper nearly closed.
,, 3	370°	528°, damper again open (70 inches).
,, 4	365°	435°, damper nearly closed.
,, 5	360°	380°, damper and fire doors closed.
,, 6	340°	380°, do. do.

* The weight of the cinder is supposed to be that after the separation of the clinker (considered as incombustible matter) if there be any, or $w_2 = c - p$ in which c = weight of cinder given by experiment and p weight of clinker.

We also observed that the temperature at the top part of the flue differed from that at the bottom, and that (as might be expected) this difference was materially influenced by the draught. With the damper nearly closed, it was 360° at the bottom, and 415° at the top; and with the damper open (70 in.), it was 430° at bottom, and 415° at top. The fire at the time of making these observations had burnt down very low, being at the close of the day's work. In drawing the samples of gases for analysis from the chimney shaft, we also observed that the temperature varied according to the particular part in the chimney where the thermometer was placed, the centre being lower always than the sides—a variation most probably due to the down currents of cold air, which, unless guarded against, might vitiate the results obtained from the analysis of the products of combustion.

By the evidence obtained through the observations made with the naked thermometer in the flue, it would appear that not only a considerable quantity of heat was absorbed and lost by the use of iron tubes, but that the variations, either in increase or decrease, were only shown after the tubes had been exposed to their action for some time; the one (naked) thermometer indicating *immediately* an *extreme* difference of 150°, while the other (in the tube H) only gave an *extreme* difference of 40°, and being but very slightly and slowly affected by the difference of draft, which at once was seen by the action of the *naked* thermometer.

Finding such a loss sustained by the use of iron tubes and oil, we made use of a fusible metallic compound instead of the oil, which we found gave much more ready intimation of the changes of temperature, but which still gave us a far lower degree of heat than that given by the naked thermometer.

By an arrangement of wires of different thermo-electric relations, we constructed a rough thermo-electric thermometer, which was connected with the flues, and gave us sufficient evidence of its applicability for such purposes, as to induce us to think that it will form a very excellent and delicate indicator of temperature, especially where sudden variations occur, and where the heat is too great for the use of mercurial thermometers. Our investigation experiments being at this time brought to a close, we were not able to carry out this application into practical operation.

These observations were made, and are now given more for the purpose of calling attention to the subjects, than from a desire to claim any definite value for them.

EXPERIMENT for determining the COEFFICIENT of the EVAPORATIVE POWER of WOOD, and the FORMULÆ used in calculating the results, by Mr. J. ARTHUR PHILLIPS.

In the formulæ for calculating the evaporative power of wood and coal, as given in the preceding chapter, no notice is taken of the expansion and contraction of the water in the boiler from an increase or diminution of temperature; and therefore, although sufficiently exact for practical purposes, they are not strictly correct.

In order to make this allowance, it will be necessary to ascertain what weight of water the boiler contains, when filled, to the normal point at the various temperatures within the extremes of observed difference.

With this view, the boiler was filled to the normal point with water at the temperature of 70° Fahrenheit, when it was found to contain 4730lbs.; the fire was then lighted, and the increase of heat noted by means of a thermometer placed in the tube L, containing mercury; the water was soon observed to expand and rise slowly above the normal point, and at each successive elevation of 20° marked by the thermometer the excess of water was drawn off down to the normal point, by means of the cock R″, and weighed; these successive weighings furnished the data from which the following Table has been calculated.

TABLE showing the Expansion of Water in the Boiler at different Temperatures.

Temperature of Water, Fahrenheit.	Ratio of apparent to real Weight.	Actual Weight of Water in Boiler when filled to Normal Point.	Difference between actual and apparent Weight.
°		Lbs.	
70	1·0000	4730·000	0·000
80	0·9996	4728·108	1·892
90	0·9992	4726·216	3·784
100	0·9987	4723·950	6·050
110	0·9983	4721·960	8·040
120	0·9979	4719·097	10·903
130	0·9974	4717·795	12·205
140	0·9971	4715·283	14·717
150	0·9967	4714·012	15·988
160	0·9954	4708·242	21·758
170	0·9940	4701·620	28·380
180	0·9923	4693·579	36·421
190	0·9901	4683·173	46·827
200	0·9879	4672·767	57·233
202	0·9869	4668·037	61·963
204	0·9859	4663·307	66·693
206	0·9849	4658·577	71·423
208	0·9839	4653·847	76·153
210	0·9829	4649·117	80·883
212	0·9819	4644·387	85·613

Between the temperatures of 150° and 212° a variation of 69·625 lbs. in the weight of water contained in the boiler will be observed, which, though an extreme case, clearly shows that, even when a difference of 10° has been observed between the initial and final temperatures, allowance should be made for it in the calculations.

It was also thought advisable to ascertain with great accuracy the evaporative power of the wood used in lighting the fires; for this being a constant in all the experiments, it is obviously of great importance.

Determination of the heating powers of wood; method of correction for the wood used in lighting the fire.

In order to ascertain the evaporative power of wood when applied to this particular boiler, it was filled to the normal point with water at the temperature of 212° Fahrenheit; the fire was then supplied with wood during eight consecutive hours, at the expiration of which time it was allowed to burn slowly out, and on the following morning water was let down from the tanks, till it again attained the normal level marked on the water-gauge of the boiler, when it was found that the mixture had a temperature of 200° Fahrenheit. It was also ascertained that from the commencement of the experiment 1800 lbs. of water had been let down from the tanks, and that 639 lbs. of wood had been consumed.

From these data, then, we have to find the coefficient required; and this may be done in the following manner:—

A. On consulting the table which has been constructed for this purpose, we find that the boiler contains more water, by 28·380 lbs., at the close of the experiment than it did at its commencement; in order, therefore, to ascertain the quantity actually evaporated, from that let down into the boiler during the experiment, we have 1800−28·380=1771·62 lbs., which is the actual weight of water which has been evaporated.

But as in this experiment the water is supposed to be evaporated from 212°, we have other considerations to attend to, and the second is, the allowance to be made for the quantity of heat necessary to raise 1771·62 lbs. of water from 70°, the mean temperature of the tanks, to the temperature of ebullition; we, therefore, multiply 1771·62 by 142·88, which is the quantity of heat expressed in degrees of Fahrenheit necessary to raise the former to the latter temperature*, and the result, 253·129, shows how many pounds of water at 0° would be raised 1° in temperature by the same quantity of caloric. We have, therefore, only to divide this sum by 965·7, the co-efficient of the latent heat of steam at the temperature of 212°, to find its equivalent value in water evaporated from that temperature; this we find to be 262·12, which should be added to 1771·62 found in Section A. Thus we have 1771·62+262·12= 2033·74 lbs.

C. Another cause of error to be considered and allowed, is that which arises from the difference in the temperature of the water in the boiler at the beginning and close of the experiment.

In the present case, the water, when the experiment was completed, was 12° colder than at its commencement. And thus we have to subtract from the water evaporated at 212° a quantity equivalent to the heat which would be required to raise the same weight of water as that contained in the boiler, at the commencement of the experiment, from the final to the initial temperature. We have, therefore, to seek, in the table already alluded to, the weight of water corresponding to the initial temperature: which, in the present instance, we find to be 4644·387, which, being multiplied by 12·1308, and divided by 965·7, gives 58·340, the weight of water which, if evaporated from 212°, would be equivalent to raising 4644·387 lbs. of water from 0° to 12°, and this should evidently be subtracted from 1771·62 + 262·12 = 2033·73 lbs. resulting from the preceding operations. We have then 2033·73 − 58·340 = 1975·400 lbs.

D. There now remains to be made, a slight correction for 28·380 lbs. of water subtracted in the first operation: for this weight has evidently been raised from 70° to 200°, and for which allowance must be made.

We find by the usual formulæ, the value of this to be 3·617 lbs., which must be added to 1975·400 already found. We have then 1975·400 + 3·617 = 1979·017 lbs., which, divided by the weight of wood employed, will give the coefficient of its evaporative power, which we find to be 3·097.†

These operations can be conveniently expressed by the following formulæ:—

$$\frac{(W + w - w')(l + t) + \frac{1}{2}wt' + (w' - w)t''}{P\,l} = E$$

In which W represents the total quantity of water let down from the tanks into the boiler during the experiment.

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* It will be found from Table II., that the mean specific heat of water between 70° and 212° is 1·0062.

† A similar experiment during which 1056 lbs of wood was consumed gave the number 3·036. These results are much lower than those obtained by other experimentalists; but this difference probably arises from the smallness and dampness of the wood employed, added to the great loss of heat occasioned by the very quick draught necessary to carry off the smoke evolved. The frequent opening of the fire doors for the purpose of charging must also have contributed to the same effect.

w = The weight of water (as found in the table) contained in the boiler at the commencment of the experiment.

w' = The weight of water contained in the boiler at the close of the experiment.

l = Coefficient of the latent heat of steam.

t = Quantity of heat (expressed in degrees of Farhenheit), necessary to raise the water in the tanks from its mean temperature, to that at which it has been evaporated.

t' = The quantity of heat necessary to raise the initial to the final temperature of the water in the boiler.

t'' = Quantity of heat necessary to raise water at the temperature of the tanks to the final temperature of the water in the boiler.

P = Weight of combustible consumed during the experiment.

E = The coefficient of the heating power of wood. It is here to be remarked that, when the initial is lower than the final temperature, the formula becomes—

$$\frac{(W + w - w')\, l + W t + w t' + (w' - w)\, t''}{P\, l} = E$$

In which each term retains its original value, except the last; in which t'' is replaced by t''', which is the quantity of heat necessary to raise the final temperature to the temperature at which the water was evaporated; and must be regarded as having a negative value, whilst t' becomes positive.

If, then, we call q the weight of wood employed in lighting the fire, the formulæ for estimating the evaporative power of coals will be—

$$\frac{(W - E q + w - w')\, l + (W + w - w')\, t + w t' + (w' -)\, t''}{P\, l} = E'$$

and

$$\frac{(W - E q + w - w')\, l + W t + w t' + (w' - w)\, t'''}{P\, l} = E'$$

It might perhaps appear that an allowance should be made in these formulæ for the heat absorbed by the apparatus employed for the purpose of equalizing the temperature of the water in the boiler, as it is evident that the tubes Q Q Q, &c. must become heated during the process of pumping the water from the bottom of the boiler, in order to distribute it on the surface; but, by the following considerations, it becomes evident that this quantity is so extremely small as to be safely neglected in the calculations.

Firstly,—The pumping of the water is always finished previously to establishing the normal level by letting down the water from the tanks; therefore the whole, or by far the greater portion of the heat, absorbed by the apparatus is again yielded to the cold water as it passes through them. It is also evident that the value of this difference may be easily calculated from the following data. The apparatus is formed of 300 lbs. of iron and 35·5 lbs. of copper: if, then, we take the specific heat of iron at 0·11379, and that of copper at 0·09515, we find that the calorific value of the whole apparatus will be equal to 37·5141bs. of water.

It was shown, by a mean of three experiments, that the cold water let down into the boiler had absorbed from the apparatus 2° of heat more than had been communicated to it during the process of pumping; and as the value of this difference on the coefficient of the evaporative power of a combustible will be of the form $\frac{\pi\,\theta}{Pl}$*, we find that for an ordinary operation in which 350 lbs. of fuel have been consumed, and 3500 lbs. of water evaporated, this difference will influence the result in the proportion of 10·0000 to 10·0002, which is infinitely too small to merit attention in a practical investigation like the present.

The latent heat of steam between the temperature of 32 and 446° Fahrenheit, as well as the mean specific heat of water between 32° and T. and the specific heat of the same fluid from T to T + d T, will be found in the following Table, extracted from "Regnault's Mémoire," published in the "Transactions de l'Institut de France," tome xxi.

These numbers were employed in all the calculations from the foregoing formulæ, and corrections have constantly been made for the expansion and contraction of the water in the tanks, as well as of the tanks themselves, whenever the temperature has varied 2° from that at which the water-guages were graduated.

These corrections were made by means of the Table No. III., calculated from the known expansion and contraction of water between the temperatures of 40° and 80° Fahrenheit, and the cubic contraction of wrought-iron vessels between the same temperatures.

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* π = Calorific value of the apparatus. θ = Difference of temperatures. P = weight of combustible employed. l = Latent heat of steam.

TABLE No. II.

Air Thermometer, Centigrade.	Mercurial, Centigrade.	Number of Unities of Heat abandoned by one kilo. of Water in descending from T to 0°.	Air Thermometer, Fahrenheit.	Mercurial, Fahrenheit.	Number of Unities of Heat contained in one pound of Water at T°.	Mean Specific Heat of Water between 0° and T Cent. or between 32° and T Fahr.	Specific Heat of Water from T to T + dT.	Latent Heat of Vapour saturated to the temperature T.	
								Centigrade.	Fahrenheit.
°	°		°	°					
0	..	0·000	32	..	32·000	..	1·0000	606·5	1091·7
10	..	10·002	50	..	50·003	1·0002	1·0005	599·5	1079·1
20	..	20·010	68	..	68·018	1·0005	1·0012	592·6	1066·7
30	..	30·026	86	..	86·046	1·0009	1·0020	585·7	1054·2
40	..	40·051	104	..	104·091	1·0013	1·0030	578·7	1041·6
50	50·2	50·087	122	122·36	122·156	1·0017	1·0042	571·6	1028·9
60	..	60·137	140	..	140·246	1·0023	1·0056	564·7	1016·4
70	..	70·210	158	..	158·381	1·0030	1·0072	557·6	1003·7
80	..	80·282	176	..	176·507	1·0035	1·0089	550·6	991·1
90	..	90·381	194	..	194·685	1·0042	1·0109	543·5	978·3
100	100·0	100·500	212	212·0	212·900	1·0050	1·0130	536·5	965·7
110	..	110·641	230	..	231·153	1·0058	1·0153	529·4	952·9
120	..	120·806	248	..	249·450	1·0067	1·0177	522·3	940·1
130	..	130·997	266	..	267·794	1·0076	1·0204	515·1	927·2
140	..	141·215	284	..	286·187	1·0087	1·0232	508·0	914·4
150	150·0	151·462	302	302·0	304·632	1·0097	1·0262	500·7	901·2
160	..	161·741	320	..	323·133	1·0109	1·0294	493·6	888·5
170	..	172·052	338	..	341·693	1·0121	1·0328	486·2	875·1
180	..	182·398	356	..	360·316	1·0133	1·0364	479·0	862·2
190	..	192·779	374	..	379·002	1·0146	1·0401	471·6	848·9
200	200·0	203·200	392	392·0	397·760	1·0160	1·0440	464·3	835·7
210	..	213 660	410	..	416·588	1·0174	1·0481	456·8	822·2
220	..	224·162	428	..	435·480	1·0189	1·0524	449·4	808·9
230	..	234·708	446	..	454·474	1·0204	1·0568	441·9	795·4

TABLE No. III.

CORRECTION for EXPANSION and CONTRACTION of WATER in the TANKS, taking 70° as the normal temperature.

Temperature, Fahrenheit.	Actual weight of an Unity of Water.	Temperature, Fahrenheit.	Actual weight of an Unity of Water.
°		°	
40	1·001464	62	1·000712
42	1·001451	64	1·000534
44	1·001439	66	1·000356
46	1·001426	68	1·000178
48	1·001414	70	1·000000
50	1·001401	72	·999763
52	1·001294	74	·999527
54	1·001196	76	·999290
56	1·001094	78	·999054
58	1·000992	80	·998818
60	1·000890		

SECTION IV., PART I.—CHEMICAL ANALYSES of COALS, by Mr. F. C. WRIGHTSON.

D.—IN the analyses of the coals great care was taken to have a fair average, by breaking up a large quantity of the coal, and from that selecting a smaller specimen for examination.

As a control experiment, and to see how far the average differed from the best sample, a portion of pure coal was selected, and also analysed.

Hygrometric Water was determined by drying the coal in a water bath, and ascertaining the loss.

Carbon and Hydrogen.—More accurate results were obtained by operating upon three or four grains than upon a larger quantity. The coal was reduced to an impalpable powder, dried and mixed in a combustion tube with dry chromate of lead, by means of a screw wire. The combustion was done in the ordinary way.

Nitrogen was determined by the usual plan, known to chemists as "Will and Varrentrapp's method."

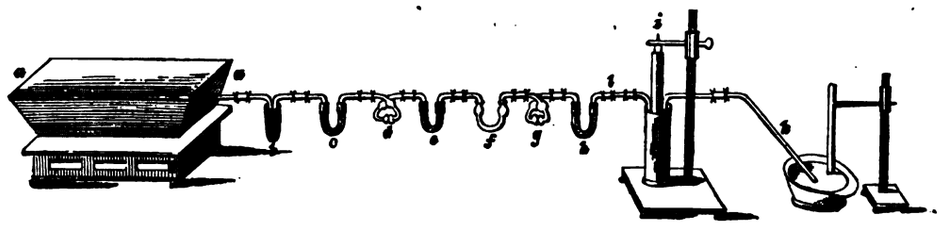
Sulphur was determined by mixing the coal with twice its weight of pure precipitated carbonate of lime, placing the mixture in a tube blown into a bulb in the middle, and burning it in a stream of oxygen gas with the aid of a spirit lamp. When completely burnt (which is readily perceived by the whiteness of the mass, and its solubility in hydrochloric acid), the whole is thrown upon a filter, the sulphate of lime washed out, and the sulphuric acid precipitated by chloride of barium, and estimated as sulphate of barytes. From this amount the quantity of sulphuric acid existing in the ashes of the coal is subtracted.

Ashes were determined by burning 15 or 20 grains of the coal in a platinum capsule over a spirit lamp, or by doing the same in a tube of green glass in a stream of oxygen gas.

Oxygen was ascertained by loss on the analysis.

Proximate Analyses.

The methods employed in these analyses are described in detail in Bunsen and Playfair's Reports on Iron Furnaces (British Association Reports, vol. xiv., p. 142), to which we have to refer. The apparatus is figured—



in which the tube *a a* contains the coal, and, after being heated to a white heat for several hours, the weight of coke left; *b* contains the tar water and ammonia, which are separated, as described in the above report, *c* being a tube filled with chloride of calcium, to retain any water and ammonia which had passed over from *b*. *d* is a tube filled with a solution of oxide of lead in potash, for the double purpose of retaining sulphuretted hydrogen and carbonic acid, which are afterwards separately determined, while *e* is a tube to retain any aqueous vapour passing over from *d*. The tube *f* contains perchloride of antimony, for the purpose of absorbing olefiant gas and the hydro-carbons; *g* a Liebig's apparatus, containing an alcoholic solution of potash, to retain any chlorinated products from *f*, and *h* an absorption apparatus, containing sulphuric acid; the tubes *i* and *k* being to obtain the uncondensed gases for future analysis.

GRAIGOLA COAL.*

Ultimate Analysis.

C. and H.—I. Coal used 0·2290 grammes, which gave 0·0780 carbonic acid, and 0·0732 water.

II. 0·4170 grammes gave 1·3065 carbonic acid, and 0·1558 water.

N.—0·8633 gave ·0573 platinum salt = 0036 nitrogen.

S.—2·3980 gave 0·1100 sulphate of barytes = ·0151 sulphur. This = 0·51°, from which 0·06 must be deducted for sulphuric acid in ash.

Ash.—0·5086 gave 0·0170 ash, and in a second experiment 0·5165 gave 0·0180 ash.

H o. 3·3295 lost at 212° ·0353 = 1·06 per cent.

			Mean.
Carbon . . .	84·31	85·44	84·87
Hydrogen . .	3·54	4·15	3·84
Nitrogen . .	0·41	..	0·41
Sulphur . . .	0·45	..	0·45
Ash	3·14	3·34	3·24
Oxygen . . .	8·15	..	7·19
	100·00		100·00

Proximate Analysis.

Coal used, 337·565; coke left, 288·390; tar, 4·200; water, 10·768. C. 0_4 = 9·440. S. H. trace—olefiant gas, 0·785; ammonia, 0·592.

Note.—The coke obtained in this analysis lost by prolonged heating, in two trials, 5·6 per cent. and 6·7 per cent.

Coke	85·5
Tar	1·2
Water	3·1
Sulphuretted hydrogen . . .	trace.
Carbonic acid	2·79
Olefiant gas and hydro-carbon . .	0·23
Ammonia	0·17
Other gases	7·01

* When the mean analysis is given, it always refers to the average specimens, not including the pure coal.

Anthracite, from T. Aubrey and Co.

Ultimate Analysis.

C. and H.—I. Coal used, 0·2763 grains. C. 0_2 = 0·9310, H. 0 = 0·0863.
II. Coal, 0·2923 grains. C. 0_2 = 0·9827. H. 0 = 0·0920.
N.—Coal, 0·9234 grains; platinum salt, 0·0313.
S.—Coal, 2·0799 grains B *a* 0, S. 0 = 1248 = 0·0172 S., or 0·82 per cent., from which 0·03 must be substracted for S. 0_3 in ash.
Ash.—0·7097 coal gave 0·0110 ash, and 0·7645 coal gave 0·0115 ash.
Water.—2·9338 lost on drying at 212° 0·0612 = 2·44 per cent.

	I.	II.	Mean.
Carbon	91·19	1·69	91·44
Hydrogen	3·44	3·49	3·46
Nitrogen	0·21	..	0·21
Sulphur	0·79	..	0·79
Oxygen	2·82	..	2·58
Ash	1·55	1·50	1·52
	100·00		100·00

Proximate Analysis.

Coal used, 326·000; coke left, 303·090; tar, none; water, 9·365; platinum salt, 8·580; sulphuret of lead, 0·940; carbonic acid, 0·212; olefiant gas, ?.

Coke	92·9
Tar	None.
Water	2·87
Ammonia	0·20
Carbonic acid	0·06
Sulphuretted hydrogen	0·04
Olefiant gas and hydro-carbon	?
Other inflammable gas	3·93

Oldcastle Fiery Vein.

Ultimate Analysis.

C. and H.—0·4430 grains coal gave 1·4247 C. 0_2 and 0·1945 H. 0.
II. 0·4995 grains coal gave 1·5860 carbonic acid and 0·2186 water.
III. 0·3055 grains pure coal gave 0·9945 C. 0_2 and 0·1365 H. 0.
N.—0·899 coal gave 0·1405 platinum salt, and 0·4200 coal gave 0·1100 platinum salt.
S.—2·172 gave 215 B *a*. 0, S. 0_3 equal to 0·29 S. or 0·13 per cent., from which 0·04 must be deducted for S. 0_3 in ash.
Ash.—0·6755 coal gave 0·0175 ash, and 0·7120 gave 0·0192 ash.
Water.—2·4314 lost at 212° 0·180.

	Average Coal.		Pure Coal.	Mean.
Carbon	87·70	86 59	88·75	87·68
Hydrogen	4·87	4·86	4·96	4·89
Nitrogen	0·99	..	1·64	1·31
Sulphur	0·09	..	..	0·09
Oxygen	3·76	..	..	3·39
Ash	2·59	2·69	..	2·64
	100·00			100·00

Proximate Analysis.

Coal used, 106·250; coke left, 84·75; tar, 6·230; water, 3·611; ammonia, 4·832; platinum salt, sulphuret of lead, 0·915; carbonic acid, 0·470; olefiant gas, 0·290.

Coke	79·8
Tar	5·86
Water	3.39
Ammonia	0·35
Carbonic acid	0·44
Sulphuretted hydrogen	0·12
Olefiant gas and hydro-carbon	0·27
Other inflammable gases	9·77

Ward's Fiery Vein.

Ultimate Analysis.

C. and H.—5·103 gave 16·440 C. 0_2 and 1805 H. 0.
N.—11·675 coal gave 1·895 platinum salt.
S.—12·585 coal gave 0·765 B *a* 0, S. 0_3.
Ash.—8·805 coal gave 0 630 ash, and 15·075 coal gave 1·050 ash.
Note.—The pure coal contained only 3·82 per cent. ash.

Water.—5·200 grammi dried at 212° lost 0·763 = 1·38 per cent.; and 25·66 grains dried at 212° lost 327 = 1·27.

Carbon	87·87
Hydrogen	3·93
Nitrogen	1·02
Sulphur	0·83
Oxygen (included in ash).	
Ash	7·04

Proximate Analysis.

236·910 coal gave 4·270 tar, 7·150 water, 7·650 platinum salt, 3·970 sulphuret of lead, 4·280 carbonic acid, 0·500 olefiant gas. The coke was lost, by an accident in experimenting.

Coke	?
Tar	1·80
Water	3·01
Ammonia	0·24
Carbonic acid	1·80
Sulphuretted hydrogen	0·21
Olefiant gas	0·21

Binea Coal.

C. and H.—4·255 coal gave 13·845 C. 0 and 1·737 H. 0.
3·255 „ „ 10·525 C. 0_2 and 1·344 H. 0.
3·955 pure „ 12·917 C. 0_2 and 1·710 H. 0.

N.—10·110 coal gave 2·350 platinum salt.

S.—15·605 „ „ 0·380 B *a* 0, S. 0_3.

Ash.—17·265 „ „ 0·690 ash.
9·095 „ „ 0·358 „
15·975 pure „ 0·380 „

Water.—61·035 coal dried at 212° gave 0·560 water. In another experiment, in which details are omitted, the water amounted to 0·82 per cent.

	Average Coal.		Pure Coal.	Mean.
Carbon	88·73	88·18	89·07	88·66
Hydrogen	4·53	4·58	4·80	4·63
Nitrogen	1·43	..	..	1·43
Sulphur	0·33	..	..	0·33
Oxygen	1·05	..	..	1·02
Ash	3·93	3·99	{2.38}	3·96
	100·00			100·00

*Proximate Analysis.**

Coal used, 313·860 gave 276·170 of coke; of tar, 6·540; of water, 14·540; of ammonia, platinum salt, 3·540; of sulphuret of lead, 2·070; of carbonic acid, 5·296; of olefiant gas and hydro-carbon, 0·985.

Coke	88·10
Tar	2·08
Water	3·58
Ammonia	0·08
Carbonic acid	1·68
Sulphuretted hydrogen	0·09
Olefiant gas	0·31
Other gases	4·08

Llangenneck.

Ultimate Analysis.

C. and H.—4·079 coal gave 12·860 C. 0_2 and 1·682 H. 0.
4 145 „ „ 13·060 „ „ 1·540 „
3·585 „ „ 11·060 „ „ 1·325
N.—8·380 „ „ 1·425 platinum salt.
S.—8·620 „ „ 185 B *a* 0, S. 0 5.
Ash.—7·293 „ „ 434 Ash.
5·719 „ „ 370 „

* In the proximate analyses the coal was not dried previous to its being heated, and therefore the water is greater than that corresponding to the oxygen formed.

	Average Coal.		Pure Coal.	Mean.
Carbon . .	85·98	85·93	84 46	85·46
Hydrogen. .	4·58	4·12	4·10	4·20
Nitrogen . .	1·07	..	..	1·07
Sulphur . .	0·29	..	..	0·29
Oxygen . .	1·17	..	..	2·44
Ash . . .	6·91	6·17	..	6·54

*Proximate Analysis.**

Coal used, 311·730; coke formed, 260·890; tar, 3·795; water, 12·701; ammonia platinum salt, 3·280; carbonic acid, 10·023; sulphuret of lead, 0·610; olefiant gas, 1·340.

Coke	83·69
Tar	1·22
Water	4·07
Ammonia.	0·08
Carbonic acid	3·21
Sulphuretted hydrogen . .	0·02
Olefiant gas	0·43
Other gases	7·28

PENTREPOTH.

Ultimate Analysis.

C. and H.—3·135 coal gave 10·188 C. 0_2 and 1·225 H. 0.
3·128 „ „ 10·155 C. 0_2 „ 1·315 H. 0.

N.—10·040 „ „ 0·310 platinum salt.

S.—Not estimated.

Ash.—6·490 gave 215 ash.
9·50 „ 325 „

	I.	II.	Mean.
Carbon . . .	88·62	88·83	88 72
Hydrogen. . .	4·34	4·67	4·50
Nitrogen . . .	0·18	..	0 18
Oxygen . . .	..	..	3·24
Ash	3·31	3·41	3·36

DALKEITH JEWEL SEAM.

C. and H.—2·935 coal gave 7·970 C. 0_2 and 1·379 H. 0.
2·854 „ „ 7·855 C. 0_2 and 1·303 H. 0.
2·680 pure „ 8·260 C. 0_2 and 1·381 H. 0.

N.—12·073 coal „ 0·200 platinum salt.

S.— 6·275 „ „ 0·155 B *a* 0, S. 0_3.

Ash.—11·892 pure „ 0·085 ash.
4·290 „ „ 0·190 „
8·315 „ „ 0·360 „

Water.—26·760 dried at 212° lost 2·505.

	Average Coal.		Pure Coal.	Mean.
Carbon . .	74·05	75·06	78·76	74·55
Hydrogen .	5·21	5·07	5·36	5·14
Nitrogen . .	0·10	..	..	0·10
Sulphur . .	0·33	..	..	0·33
Oxygen . .	15·99	..	..	15·51
Ash . . .	4·32	4·42	0·71	4·37

DALKEITH CORONATION SEAM.

C. and H.—2 761 gave 7·800 C. 0_2 and 1·927 H. 0.
2·647 „ 7·425 C. 0_2 and 1·258 H. 0.
3·743 „ 10·605 C. 0_2 and 1·722 H. 0.

N.—Too small to determine.

S.—6·125 gave 0·280 B *a* 0, S. 0_3.

Ash.—11·913 „ 0·355 ash.
7·362 „ 0·224 „
8·035 „ 0·300 „

Water.—40·105 lost at 212° 2·360.

* In some analyses the carbonic acid appears to stand in a certain ratio to the oxygen contained in the coal. This seems an exception, all the oxygen being given off as carbonic acid. However, a greater number of analyses should be compared, to draw any inference.

	Average Coal.		Pure Coal.	Mean.
Carbon . .	77·04	76·50	77·29	76·94
Hydrogen . .	5·21	5·28	5·11	5·20
Nitrogen . .	trace.	..	..	trace.
Sulphur . .	0·38	..	..	0·38
Oxygen . .	14·02	..	..	15·78
Ash . . .	3·35	3·38	2·68	3·10
	100·00			100·00

PENTREFELAN.

C. and H.—4·025 gave 12·950 C. O_2 and 1·355 H. O.
4·008 „ 12·250 C. O_2 and 1·410 „
2·573 „ 8·065 C. O_2 and 0·815 „

N.—Only traces were found.

S.—5·445 gave 0·495 B*a* 0, S. O_3.

Ash.—9·075 „ 0·550 ash.
19·153 „ 1·175 ash.
7·870 pure coal gave 0·305 ash.

	Average Coal.		Pure Coal.	Mean.
Carbon . .	87·74	83·35	85·48	85·52
Hydrogen .	3·74	3·90	3·52	3·72
Nitrogen . .	trace.	..	..	trace.
Sulphur . .	0·12	..	..	0·12
Oxygen . .	4·53	..	..	4·55
Ash . . .	{3·87}	6·06	6·13	6·09

SECTION III., PART II.—CHEMICAL ANALYSIS of the COALS by Mr. H. HOW.

ULTIMATE ANALYSIS OF COALS.

THE methods pursued for the estimation of the constituents of the coals in the following analysis were precisely identical with those already specified, with the exception of that for the determination of the sulphur. The amount of this element was ascertained by fusing about 10 grains with carbonate of soda and nitre in proper proportions, and then proceeding in the usual way for estimating sulphuric acid; this method was preferred as occupying far less time than the one before mentioned.

With regard to analysis of "pure coal," it was thought unnecessary to multiply instances of this kind, a sufficient number being already brought forward to show generally the nature of different parts of a coal, and a knowledge of this variation in every instance would not possess a practical utility great enough to justify the occupation of the considerable time requisite for the extension of the investigation in this particular direction: while the fact of my being aware of the existence of such a want of uniformity has made me most careful to obtain such an average sample of each coal as shall express most fairly upon analysis the real value of the mass; the following are the results:—

EXPERIMENTAL NUMBERS IN THE ANALYSES.

POWELL'S DUFFRYN COAL.

This coal contained 1·13 per cent. of water; dried at 212°.

Coal.
2·15 grs. yielded 6·97 carbonic acid and 0·88 water.
2·03 „ 6·56 „ „
11·31 „ 0·36 ash.
10·78 „ 0·36 „
8·73 „ 2·02 chloride of platinum and ammonium.
6·93 „ 0·926 sulphate of baryta.

MYNYDD NEWYDD.

This coal yielded 0·61 per cent. of water: dried at 212° Fah.

Coal.
3·56 grs. gave 11·00 carbonic acid and 1·80 water.
3·49 „ 10·90 „ 1·86 „
12·20 „ 0·40 ash.
4·35 „ 0·14 „
10·00 „ 2·52 bichloride of platinum and ammonium.
6·63 „ 0·615 sulphate of baryta.

Coal swells up much on heating, burns with much flame, and leaves a bright red ash.

Three-quarter Rock Vein.

This coal yielded 1·67 per cent. of water: dried at 212° Fah.

Coal.		
3·65	grs. gave	10·10 carbonic acid and 1·65 water.
3·96	,,	10·87 ,, 1·73 ,,
9·99	,,	1·07 ash.
9·81	,,	1·10 ,,
13·40	,,	2 36 bichloride of platinum and ammonium.
8·33	,,	1·87 sulphate of baryta.

Coal swells up much in burning; leaves a grey ash.

Park End Coals, Lydney.

This coal contained 2·78 per cent. water: dried at 212° Fah.

Coal.		
3·15	grs. gave	8·47 carbonic acid and 1·6 water.
2·63	,,	7·11 ,, 1·36 ,,
8·35	,,	0 83 ash.
7·46	,,	0·75 ,,
12·65	,,	4·15 platinum salt.
8·13	,,	1·466 sulphate of baryta.

Ash had a reddish colour.

Cwm Frood Rock Vein.

This coal gave 1·12 per cent. water: dried at 212° Fah.

Coal.		
3·09	grs. yielded	9·26 carbonic acid and 1·6 water.
3·37	,,	10·23 ,, 1·8 ,,
7·90	,,	0·47 ash.
7·43	,,	0·45 ,,
9·90	,,	1·76 platinum salt.
10·42	,,	1·02 sulphate of baryta.

Cwm Nanty-Gros.

This coal yielded 0·9 per cent. water: dried at 212° Fah.

Coal.		
3·74	grs. gave	10·72 carbonic acid and 1·93 water.
3·46	,,	9·97 ,, 1·70 ,,
6·60	,,	0·37 ash.
6·23	,,	0·35 ,,
7·72	,,	2·30 platinum salt.
11·70	,,	2·665 sulphate baryta.

Coal swells up much in burning, and leaves a red or pink ash.

Wylam's Patent Fuel.

This fuel contained 1·38 per cent. water: dried at 212° Fah.

Fuel.		
3·46	grs. gave	10·10 carbonic acid, and 1·7 water.
2·25	,,	6·62 ,, and 1·17 ,,
7·33	,,	0·36 ash.
5·64	,,	0·27 ,,
10·47	,,	2·89 platinum salt of ammonia.
8·17	,,	0·803 sulphate of baryta.

Ash had a reddish grey colour.

Grangemouth Coal.

This coal yielded 6·42 per cent. water: dried at 212° Fah.

Coal.		
3·80	grs. gave	11·16 carbonic acid, and 1·82 water.
3·75	,,	10·95 ,, and 1·77 ,,
6·80	,,	0·24 ash.
6·50	,,	0·23 ,,
10·64	,,	2·30 platinum salt.
7·73	,,	0·842 sulphate of baryta.

Ash had a reddish yellow colour.

Broomhill Coal.

This coal yielded 9·31 per cent. water: dried at 212° Fah.

Coal.		
3·035	grs. gave	9·06 carbonic acid, and 1·70 water.
2·85	,,	8·57 ,, and 1·57 ,,
10·52	,,	0·33 ash.
9·25	,,	0·28 ,,
9·34	,,	2·71 platinum salt.
7·01	,,	1·49 sulphate of baryta.

Ash pale red.

Resolven.

This coal yielded 1·55 per cent. water: dried at 212° Fah.

Coal.		
3·85	grs. gave	11·2 carbonic acid, and 1·55 water.
3·53	,,	,, 1·60 ,,
11·31	,,	1·07 ash.
8·32	,,	0·78 ,,
9·08	,,	2·07 platinum salt of ammonia.
8·85	,,	3·39 sulphate of baryta.

Ash was reddish brown.

Pontypool.

This coal yielded 1·6 per cent. water: dried at 212° Fa

Coal.		
2·59	grs. gave	7·65 carbonic acid, and 1·29 water.
2·28	,,	6·76 ,, and 1·19 ,,
8·57	,,	0·48 ash.
13·19	,,	0·72 ,,
7·41	,,	1·60 platinum salt.
5·04	,,	0·895 sulphate of baryta.

Bedwas.

This coal contained 1·28 per cent. water: dried at 212° Fah.

Coal.		
2·18	grs. gave	6·45 carbonic acid, and 1·16 water.
2·18	,,	6·44 ,, and 1·20 ,,
11·36	,,	0·80 ash.
6·72	,,	0·46 ,,
8·66	,,	1·98 platinum salt.
4·82	,,	1·298 sulphate of baryta.
5·48	,,	1·48 ,,

Porthmawr Rock Vein.

This coal contained 1·7 per cent. water: dried at 212° Fah.

Coal.		
3·42	grs. gave	9·53 carbonic acid, and 1·47 water.
3·13	,,	8·61 ,, and 1·41 ,,
10·73	,,	1·59 ash.
5·67	,,	0·83 ,,
8·97	,,	1·88 platinum salt.
7·36	,,	0·62 sulphate of baryta.

Ash left was of a pearly white appearance.

Warlich's Patent Fuel.

This fuel yielded 0·92 per cent. water: dried at 212° Fah.

Fuel.		
3·49	grs. gave	11·49 carbonic acid, and 1·85 water.
2·9	,,	9·60 ,, and 1·37 ,,
7·51	,,	0·22 ash.
8·57	,,	0·25 ,,
4·55	,,	0·566 sulphate of baryta.

This fuel swelled a little on heating; left a red ash.

Bell's Patent Fuel.

Gave 0·9 per cent. water: dried at 212° Fah.

Fuel.		
3·84	grs. gave	12·33 carbonic acid, and 1·81 water.
3·96	,,	12·81 ,, and 1·86 ,,
5·63	,,	0·27 ash.
7·60	,,	0·39 ,,
13·53	,,	1·84 platinum salt.
8·80	,,	0·517 sulphate of baryta.

This fuel swells up very much, and leaves, on incineration, a grey ash.

Ebbw Vale Coal.

This coal contained 1·34 per cent water: dried at 212° Fah.

Coal.			
3·10	grs. gave	10·15	carbonic acid and 1·46 water.
3·19	„ „	10·56	„ „ and 1·46 „
13·73	„ „	0·21	ash.
8·14	„ „	0·12	„
8·12	„ „	2·80	platinum salt of ammonia.
7·48	„ „	0·57	sulphate of bartya.

Ash pale red.

Coleshill.

This coal contained 4·91 per cent. water: dried at 212° Fah.

Coal.			
3·99	grs. gave	10·82	carbonic acid.
3·82	„ „	10 33	„ „ and 1·77 water,
5·01	„ „	0·44	ash.
11·36	„ „	1·03	„
12·76	„ „	3·10	platinum salt.
7·31	„ „	1·34	sulphate of baryta.

Coal burned without swelling, gave a great deal of smoke; ash left, on incineration, was greyish white.

Wallsend Elgin.

This coal contained 2·49 water per cent.: dried at 212° Fah.

Coal.			
3·96	grs. gave	11·02	carbonic acid and 1·81 water.
4·26	„ „	11·92	„ „ and 1·96 „
6·58	„ „	0·70	ash.
6·55	„ „	0·71	„
6·70	„ „	0·852	sulphate of baryta.
8·76	„ „	1·97	platinum salt of ammonia.

Coal burned without swelling at all, gave much smoke, left a yellowish white ash.

Fordel Splint Coal.

This coal contained 8·4 per cent. water: dried at 212° Fah.

Coal.			
4·26	grs. gave	12·41	carbonic acid and 2·11 water.
4·21	„ „	12·31	„ „
10·91	„ „	0·42	ash.
7·68	„ „	0·32	„
10·62	„ „	1·96	platinum salt of ammonia.
8·54	„ „	0·95	sulphate of baryta.

Coal burned without swelling, gave much flame; left a wite ash.

Slieverdaugh Coal. Anthracitic.

This coal contained 4·93 per cent. water: dried at 212° Fah.

Coal.			
3·53	grs. gave	10·38	carbonic acid and 0·67 water.
3·54	„ „	10·37	„ „ and 0·80 „
10·09	„ „	1·10	ash.
9·01	„ „	0·97	„
14·75	„ „	0·56	platinum salt of ammonia.
9·77	„ „	4·968	sulphate of baryta.

Coal burned without smoke or intumescence; left a red brown ash.

Coal from Juan Fernandez.

It contained 6·00 per cent. water: dried at 212° Fah.

Coal.			
3·5	grs. gave	9·08	carbonic acid and 1·76 water.
12·64	„ „	1·29	ash.
7·52	„ „	0·75	„

The sulphur and nitrogen were not determined in this coal.

The experimental numbers given above, when calculated upon in the usual manner for per centage weights, lead to the results which are embodied in the following table:—

TABLE showing the per centage composition of the Coals analysed, as calculated from the numbers before given.

Name or Locality of Coal.	Carbon.		Hydrogen.		Ash.		Sulphur.	Nitrogen.
	I.	II.	I.	II.	I.	II.		
Powell's Duffryn . .	88·4	88·12	4·54	4·81	3·18	3·34	1·77	1·45
Mynydd Newydd . .	84·26	85·16	5·61	5·92	3·27	3·21	1·21	1·56
Three-Quarter Rock Vein .	75·45	74·85	5·02	4·85	10·71	11·21	2·85	1·07
Park End, Lydney . .	73·32	73·72	5·64	5·74	9·95	10·05	2·27	2·04
Cwm Frood Rock Vein .	81·72	82·78	5·75	5·93	5·95	6·05	1·22	1·11
Cwm Nanty Gros . .	78·57	78·16	5·45	5·73	5·60	5·61	3·01	1·86
Grangemouth . . .	80·09	79·62	5·32	5·24	3·52	3·53	1·42	1·35
Broomhill . . .	81·40	82·00	6·22	6·12	3·13	3·02	2·85	1·84
Wylam's Patent Fuel .	79·60	80·22	5·61	5·77	4·91	4·78	1·25	1·68
Resolven . . .	79·33	lost	4·47	5·03	9·46	9·37	5·07	1·38
Pontypool . . .	80·85	80·54	5·79	5·53	5·60	5·45	2·39	1·35
Bedwas	80·68	80·55	5·91	6·11	7·04	6·84	3·70	1·44
Porthmawr Rock Vein .	74·39	75·01	4·58	5·00	14·81	14·63	0·91	1·28
Warlich's Patent Fuel .	90·26	89·78	5·24	5.88	2·92	2·90	1·63	trace.
Bell's Patent Fuel .	87·56	88·21	5·23	5·21	4 79	5·13	0·71	0·81
Ebbw Vale . . .	89·28	90 27	5·08	5·23	1 53	1·47	1·02	2·16
Wallsend Elgin . .	75·88	76·30	5·33	5.11	10·63	10·78	1·53	1·41
Maxwell's Coleshill . .	73·95	73·74	5·14	lost	8·78	9·06	2·34	1·47
Fordel Splint . . .	79·44	79·73	5·50	lost	3·84	4·16	1·46	1·13
Slievardagh . . .	80·18	79·88	2·10	2·50	10·90	10·71	6·76	0·23

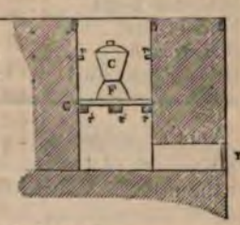
The mean results and the amount of oxygen per cent.. as well as the quantity of oxygen required to consume the combustible ingredients of the coals, are given in the body of the Report, page .

SECTION IV., PART III.—CALORIFIC VALUES of the COALS, by Mr. J. ARTHUR PHILLIPS,

LITHARGE EXPERIMENTS.

IN order further to test the calorific properties of the coals experimented on, as well as to compare their theoretic and economical values, a series of experiments was made relative to the quantity of litharge reduced by a given weight of each coal.

For this purpose we employed the furnace E, plates 1 and 2, which contains three distinct apertures, *s s s*, respectively 10½, 8, and 6 inches in diameter; and in which a grating for the support of charcoal can be placed, either at the depth of 6 or 12 inches from the surface, by means of iron pegs, according to the degree of heat required.



This arrangement will be probably better understood by reference to the annexed woodcut, in which *r r* and *r' r' r'* represent the iron pegs; Y the sliding door for regulating the draught, and G the grating. The crucible C, containing the mixture of litharge and pulverized coal, is placed on the support F.

This method of testing the calorific effects of a combustible is founded on the assumption, now pretty generally admitted, that its value is in direct ratio with the quantity of oxygen necessary to consume it.

If, then, a combustible in a fine state of division be ignited with the oxide of an easily fusible metal which yields readily its oxygen, it is evident that the weight of the button obtained will also be in proportion to the amount of oxygen abstracted from the oxide, thus affording an easy method of comparing the heating powers of different combustibles.

Experiments of this description, however, require to be conducted with extreme precaution, in order to insure success; as, in the first place, any trifling error in the observed weight of the combustible is multiplied some thirty times on the resulting button of lead. Secondly, the substance requires to be in a state of extreme division; and thirdly, every precaution should be taken to avoid the action of the reducing gases of the furnace. In order therefore to remove these causes of error, we proceeded as follows:—

Five grains of the substance, powdered and sifted through the finest wire gauze, were intimately mixed on a sheet of glazed paper, with about 1500 grains of litharge, which was introduced into a perfectly clean earthen crucible, and on the top of this was again added about 500 grains of pure litharge. The cover was then luted on with fine fire-clay, with which the whole outside of the crucible was also coated, in order to render it impervious to the reducing gases of the furnace. The crucible was then brought near the fire to dry, and when all the water had evaporated, it was placed in a furnace in which a charcoal fire was already lighted, and allowed to remain about 15 minutes; the cone *a*, plate 2, was then placed over the furnace for the purpose of increasing the draught; at the expiration of ten minutes it was again removed, and the crucible taken out to cool. When it had sufficiently cooled, it was broken, and the button of lead extracted, cleaned, and weighed. With these precautions, the three experiments which were made on each coal were always found to agree very closely, particularly when the substance operated on was not highly bituminous, in which case it becomes more difficult to operate with certainty.

The results of these experiments have been thrown into the following table, in which, although the results obtained from the same coals will be found to agree pretty closely, yet considerable difference will be observed in the relative weights of the buttons of lead produced by the various coals, and their economic values as shown by actual experiment under the boiler. It is, however, probable that these apparent discrepancies proceeded rather from difference of mechanical structure than from any chemical difference of composition:—

EXPERIMENTS WITH LITHARGE.

Name of Coal.	Quantity operated on.	Gave, of Lead—			Mean.
Dalkeith Jewel Seam	5 Grs.	128·6	133·3	134·5	132·1
,, Coronation Seam	,,	122·23	123·4	122·9	122·8
Pentrefellin	,,	152·7	152·1	153 0	152·6
Powell's Duffryn	,,	150·2	149·7	150·3	150·0
Graigola	,,	160·7	160·4	160·2	160·4
Llangenock	,,	163·4	163·2	163·0	163·2
Ward's Fiery Vein	,,	157·7	157·5	156·8	157·3
Binea	,,	158·2	159·2	157·4	158·2
Oldcastle Fiery Vein	,,	156·7	157·2	157·4	157·1
Anthracite, James and Aubrey's	,,	167·0	167·6	167·6	167 4
Mynydd Newydd	,,	151·2	151·9	152·2	151·7
Grangemouth	,,	142·6	142·3	142·3	142·4
Resolven	,,	160·8	160·9	160·9	160·8
Cwm Nanty-Gros	,,	149·3	147·2	148·9	148·4
Pentripoth	,,	158·1	153·5	155·9	155·8
Lydney	,,	129·4	130·2	129·5	129·7
Wylam's Patent Fuel	,,	145·0	143·9	143·5	144·1
Cwm Frood Rock Vein	,,	142·2	141·4	141·1	141·5
Broomhill	,,	127·0	126·1	126·9	126·6
Three-Quarter Rock Vein	,,	133·0	133·2	133·2	133·1
Warlich's Patent Fuel	,,	158·9	156·0	157·6	157·5
Pontypool	,,	137·3	138·0	136·7	137·3
Porthmawr Rock Vein	,,	123·4	123·6	124·7	123·9
Bedwas	,,	141·3	140 7	..	141·0
Ebbw Vale	,,	159·4	160·0	160·5	159·9
Coleshill	,,	131·0	130·5	130·7	130·7
Wallsend Elgin	,,	146·0	145·8	144·1	145·3
Fordel Splint	,,	145·2	142 3	147·5	145·0
Slievardagh	,,	151·7	150·0	149·8	150·5
Bell's Patent Fuel	,,	141·4	143·4	145·6	142·6

Another subject of importance in a practical investigation into the properties of coals is, the composition of the incombusible matters which they contain as materially affecting their action on the metals. This subject, although unquestionably of more importance to the metallurgist than to the engineer, is far from being uninteresting to the latter; as from the composition of the ash contained in a coal, he may safely infer the effects which will be produced on the grate and boiler by its employment. The time necessary to execute these analyses precluded the possibility of their being made in every case; but it is to be hoped that the results of the analysis of the ashes of eight different coals, as embodied in the following table, may serve to illustrate the subject, in case it should be thought proper to extend the inquiry in this direction.

In these experiments the ashes were obtained for analysis by burning off the combustible matters in a muffle, and then igniting the residue with carbonate of potassa as an ordinary silicate, the analyses were afterwards proceeded with, according to the usual routine employed in such cases.

ANALYSES of INCOMBUSTIBLE MATTERS in the ASHES of various COALS.

Name of Coal.	Silica.	Alumina and Oxide of Iron.	Lime.	Magnesia.	Sulphuric Acid.	Phosphoric Acid.	Per Centage Total.	Per Centage Amount of Coke.
Pontypool	40·00	44·78	12·00	trace.	02·22	00·75	99·75	64·8
Bedwas	26·87	56·95	5·10	1·19	7·23	00·74	98·08	71·7
Warlich's Patent Fuel	25·20	57·30	6·90	trace.	7·85	..	99·41	85·1
Porthmawr	34·21	52·00	6·199	0·659	4·12	0·633	97·821	63·1
Ebbw Vale	53·00	35·01	3·94	2·20	4·89	0·88	99·92	77·5
Fordel Splint	37·60	52·00	3·73	1·10	4·14	0·68	99·45	52·03
Wallsend Elgin	61·66	24·42	2·62	1·73	8·38	1·18	99·99	58·45
Coleshill	59·27	29·09	6·02	1·35	3·84	0·40	99·97	,,

Reference to Plates.

Plate 1.—Plan of boiler-house and apparatus.
,, 2.—Longitudinal elevation of ditto, showing the boiler and tanks in section.
,, 3.—End elevation, showing fire-doors, &c.
,, 4.—Details of the safety-valves and apparatus for insuring uniformity in the temperature of the water contained in the boiler.
,, 5.—Drawings of the boiler experimented on at Par Consols Mine.

The letters of reference apply equally to each of the plates, with the exception of No. 5.

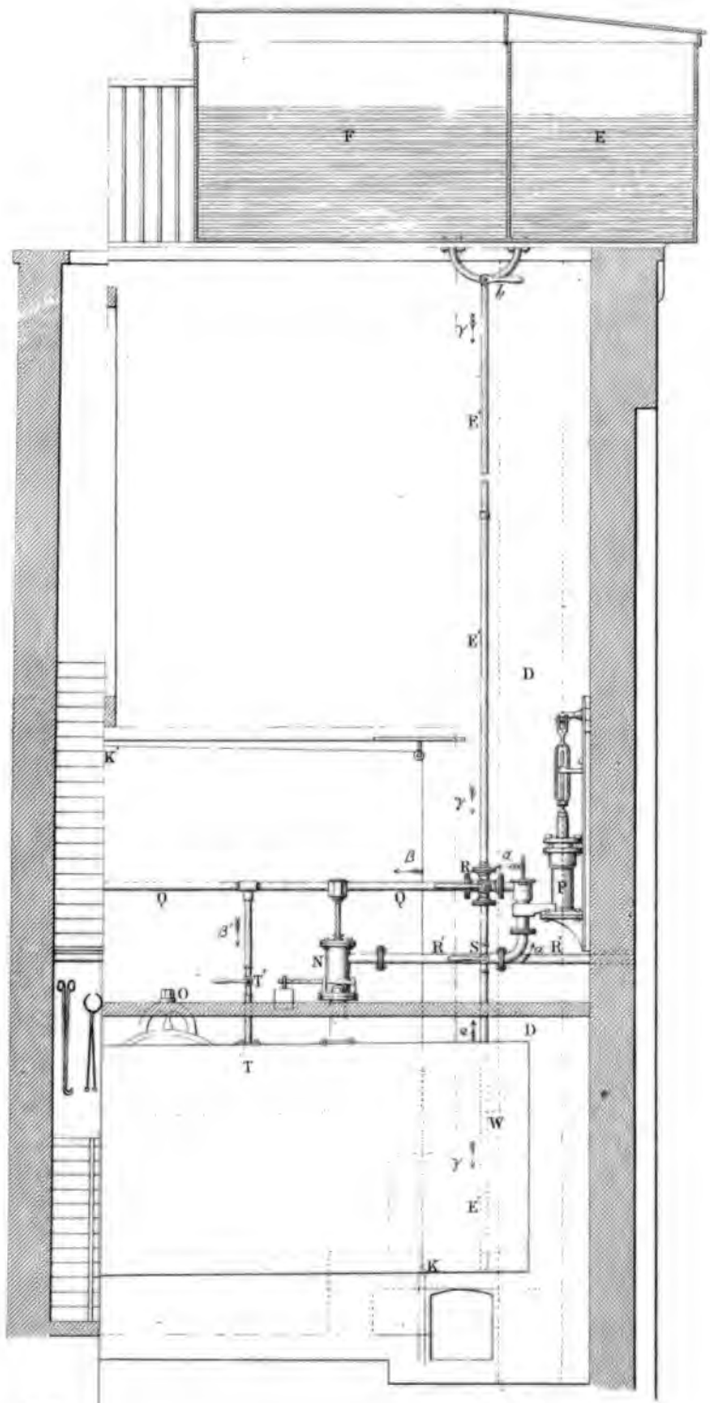
A.—Boiler-house.
B.—Laboratory of the College for Civil Engineers.
C.—Barometer-room.
D.—Chimney of the experimental boiler.
E.—Furnace used for the calorific experiments.
E, F.—Water-tanks.
e. f.—Glass tubes of the water-guages.
E′.—Feed-pipe.
G.—Main for supplying the tank E, F, with water.
H, I.—Iron tubes containing fusible metal, for the purpose of testing the heat of the flues by means of thermometers.
J.—Guage for ascertaining height of water in boiler.
j j.—Water-guages of the tanks.
j″ j″.—Stop-cocks for establishing the connexion between the tanks and water-guages.
K.—Damper.
K′, K′.—Cord for regulating damper.
L.—Iron tube for the reception of a thermometer indicating the temperature of the water in the boiler.
M.—Steam-guage.
N.—Safety-valves.
O.—Man-hole.
O′.—Weights on safety-valves.
P.—Force-pump for effecting uniformity of temperature at the beginning and close of an operation.
P′.—Counterpoise to pump-handle.
Q, Q, Q, T, T, T.—Apparatus for obtaining uniformity of temperature (described page 22).
R.—Four-way cock, used for the purpose of directing the feed-water either through the pipe Q, Q, Q, through the tube E′, or of establishing connexion with the pump P, as the case may require.
R′.—Blow-off pipe through which the steam escapes into the open air.
S.—Three-way cock used for closing the pipe E′, and at the same time establishing a connexion between the boiler and the pump P.
T, T, T.—Perforated copper bulbs for the purpose of disseminating cold water on the top of that contained in the boiler.
T′, T′, T′.—Stop-cocks for cutting off the connexion between the equalizing apparatus.
U.—Sand-bath.
U′.—Flue of ditto.
V. V.—Apparatus for the proximate analysis of coals.
X.—Tap for cleansing the boiler.
Y, Y, Y.—Sliding doors for regulating the quantities of air entering the fire-places S, S, S.
Z Z.—Drawers to contain charcoal running on friction rollers.
a, a. Moveable iron chimneys for increasing draughts of furnaces.
b.—Two-way cock for the purpose of connecting the pipe E′ with the cisterns E or F at pleasure.
b′.—Cock for regulating the supply of feed-water.
c, d, e, f, g, h′.—Sylvester's patent fire doors.

A tubular boiler, D^2, has also been erected, for the purpose of making comparative experiments, but has not been much used up to the present time.

Reference to Plate 5.

A A.—Boilers.
B, B.—Internal flues of ditto.
C C.—Apparatus for heating the feed-water previous to its entering the boilers.
D, D.—Flues.
E, E.—Feed-pipe.
F.—Fire-bars.

Plate. 2



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J. W. Lowry, sculp.t

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MUSEUM OF PRACTICAL GEOLOGY.

SECOND REPORT

ON THE

COALS SUITED TO THE STEAM NAVY.

BY

SIR HENRY DE LA BECHE, C.B., F.R.S.,

AND

DR. LYON PLAYFAIR, F.R.S.

Presented to both Houses of Parliament by Command of Her Majesty

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET,
FOR HER MAJESTY'S STATIONERY OFFICE.

1849.

SECOND REPORT.

TO THE RIGHT HONOURABLE THE EARL OF CARLISLE.

Museum of Practical Geology,
May 24, 1849.

My Lord,

We have herewith the honour to transmit a Second Report on the experiments undertaken by request of the Lords Commissioners of the Admiralty, respecting the value of different varieties of British coals for the purpose of our Naval service; and, according to your Lordship's instructions, we have forwarded a copy of this, as was done with the former Report, to the Admiralty, the expenses of the investigation being defrayed by that department.

The manner of conducting the experiments is so fully described in the last Report, that it would be unnecessary again to notice it in detail. It may, however, be desirable to remark, that the inquiry has been conducted to the best of our ability, with the view to its practical utility.

The main points to which attention has been directed are—1. The evaporative value of the fuel: 2. Its mechanical structure: 3. The bulk or space which it occupies in stowage: and 4. The chemical identification of the coals operated upon.

With regard to the experimental determination of the evaporative value of the coals, the same processes have been followed as described in our First Report. Every attention has been paid to the peculiar characters of each fuel as exhibited during its burning.

It is well known that particular coals require special modifications of the grate, and even of the boiler, to obtain their maximum result. To acquire this knowledge, it would have been necessary to try every different kind under such varying conditions; and it would have been useless, unless a series of experiments had been made, to ascertain the special circumstances most favourable to the coal under examination. The expenditure of money and time which such a course would have involved, rendered its realization quite impracticable. It was, however, possible so to regulate the draughts of air as to produce those most favourable to the peculiar characters of each coal.

To obtain these conditions, each coal was subjected to experiment for three successive days, the draught being differently arranged for each day. This course was also pursued in the experiments for the First Report. It would have been easy, and it might have given the experiments a fictitious appearance of additional value, to have performed all the work of the three days under the same conditions, as the results would have been accordant. But such agreements, while they confirmed the accuracy of the experiments, would have been of no practical value, since they would not have furnished the data necessary to determine the evaporative powers of the coals under varying circumstances of altered draught. The experiments have, therefore, been tried with different draughts, either in the proportions of 4:5:8, or when circumstances rendered it advisable of 1:2:4. By experiments with the varying draughts, it became easy to ascertain when the gases escaping from the coals were most economically consumed. The mean of the three days' trials gives, however, more correctly, the average evaporative value in steam-vessels, where the exact draught depends, to a certain extent, on circumstances over which the engineer has little immediate control.

The coals most liable to be influenced by the different adjustments for the admission of air, are those which, from their bituminous characters, are most apt to generate a large quantity of gaseous products on the first application of heat, such as the coals from the Northumberland, Durham, and Lancashire coal-fields; and it has therefore been found, that the experiments made with

them, under different areas for the admission of air, vary much more considerably, than with the less bituminous coals of the South Wales coal-field. It has even been found necessary in the highly gas-giving coals, such as the Cannel coal of Wigan, to allow air to enter behind the fire-bridge, so as to complete the combustion of the escaping gases.

Experiments were made at the suggestion of the late First Lord of the Admiralty to ascertain how far mixtures of anthracite with more bituminous coals were likely to prove advantageous in the manufacture of artificial fuel. The apparatus used in the manufacture of the contract fuel for Her Majesty's dockyard, under the patent of Mr. Warlich, having been placed at our disposal, various mixtures, as detailed in the Appendix, were made and tried under the boiler. It was, however, ascertained, that the advantages of these additions were not such as to recommend their adoption. The cementing tar, though partially carbonized by the heat of the coking ovens in which the prepared fuels are heated, was so much more combustible than the dense and difficultly burning anthracite, that the latter remained after the combustion of the former, and it therefore either accumulated on the bars in the state of powder, obstructing the draught, or, falling through the grate, escaped combustion. If thrown again on the fire, it choked the air-way, and impeded the proper action of the fuel. The evaporative power of the fuels thus prepared, was certainly found to increase according as the proportion of fixed carbon was augmented; but this would appear to arise from the fuel then assuming more of the characters of the anthracite, or coke, from which it was made. The results of the experiments pointed to the necessity of keeping an uniform character in the fuel manufactured. These experiments, which do not appear in the annexed tables, will be found detailed in the Appendix.

The following abstract of the working tables will give a general view of the relative value of the coals experimented upon. It must not, however, be taken as the exact expression of their values, without reference to the detailed description of the peculiar characters of each coal given in the Appendix. A coal, for example, may appear by this table to possess a high evaporative power, and yet it may burn so sluggishly, and require so much attention from the stoker to procure its maximum result, that the mere inspection of its evaporative value would give it a higher rank than that to which it is entitled. It is impossible, however, in an abstract to detail all the special characteristics of a coal, and therefore such a table only gives a certain amount of information, and does not render unnecessary a detailed description.

With regard to the manner in which the fuels included in the following table were selected, for examination, the same plan was followed as that adopted prior to the former Report. Careful inquiries were made at the different ports in the neighbourhood of the coal-fields, as to the kind of coal exported for steam purposes; information from steam-ship companies, in the habit of using the coals of that district was collected, and the local character of the fuel was ascertained. Circulars were then forwarded to the owners of such coals, explaining the object of the inquiry, and requesting them to furnish two tons for experiment. In most instances these were immediately responded to, and the requisite quantity was sent; in a few cases the owners did not furnish the supply necessary. It was not consistent with our instructions to make purchases, as it is usual that the coal experimented on should be delivered free of charge. It is, therefore, possible, that in the coal-fields examined, excellent varieties of fuel may not be included in our list, and this may have arisen either from the circumstance of the owners not responding to our request, or from deficient information furnished to us in our original inquiries. We have constantly endeavoured to rectify any omissions of this kind, when pointed out, and the investigation being still in progress, the opportunities for so doing will receive every attention. It is in accordance with this view that we have included in this report various coals from the South Wales coal-field which have been sent to us since the publication of the First Report. The examination has been made, as far as possible, by districts, and, in accordance with this arrangement, the Lancashire and Newcastle coal-fields have principally engaged attention in the present Report.

With these observations we would draw attention to the following abstract of the coals examined:—

TABLE I.—Showing the Economic Values of the Coals.

	Names of Coals employed in the Experiments.	Economic evaporating power or number of pounds of Water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for Fuel. lbs.	Weight of 1 cubic foot as calculated from the Density. lbs.	Ratio of B. to C., or of the economical to the theoretical Weight.	Difference per cent. between theoretical and economical Weight.	Space occupied by 1 ton in cubic feet (economic Weight).	Results of experiments on cohesive power of Coals (per centage of large Coals).	Evaporating power of the Coal after deducting for the combustible matter in the residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal. lbs.	Rate of evaporation, or number of lbs. of Water evaporated per hour. Mean.
		A.	B.	C.	D.	E.	F.	G.	H.	I.	K.
Welsh Coals.	Thomas's Merthyr	10·16	53·0	82·29	·644	55·26	42·26	57·5	10·72	538·48	520·8
	Nixon's Merthyr	9·96	51·7	82·29	·628	59·16	43·32	64·5	10·70	514·93	511·4
	Hill's Plymouth Work	9·75	51·2	84·78	·603	65·68	43·74	64·0	10·18	499·20	531·6
	Aberdare Company's Merthyr	9·73	49·3	81·73	·603	65·78	45·43	74·5	10·27	479·68	489·5
	Gadly Nine-feet Seam	9·56	54·8	83·16	·658	51·75	40·87	76·0	10·46	523·88	517·3
	Neath Abbey	9·38	59·3	83·57	·709	40·92	37·77	50·0	9·65	556·23	546·1
	Gadly Four-feet Seam	9·29	51·6	82·79	·623	60·44	43·41	68·5	10·73	479·36	400·0
	Llynvi	9·19	53·3	80·35	·663	50·56	42·02	..	9·58	429·82	399·5
	Rock Vawr	7·68	55·0	80·21	·685	45·83	40·72	65·5	7·88	422·40	397·5
Lancashire Coals.	Balcarres Arley	8·83	50·5	78·17	·646	54·79	44·35	76·0	9·09	445·91	454·1
	Blackley Hurst	8·81	48·0	78·90	·608	64·37	46·66	65·0	9·00	422·88	500·8
	Blackbrook Little Delf	8·29	51·0	78·16	·652	53·25	43·92	61·5	8·55	422·79	440·4
	Rushy Park Mine	8·08	47·0	80·04	·587	70·31	47·65	67·0	8·35	379·76	419·1
	Blackbrook Rushy Park	8·02	55·3	80·15	·689	44·93	40·50	80·5	8·26	443·50	481·2
	Johnson and Wirthington's Rushy Park	8·01	50·0	80·10	·624	60·20	44·80	69·0	8·16	400·50	454·5
	Laffak Rushy Park	7·98	52·6	84·07	·625	59·82	42·58	75·5	8·16	419·74	435·0
	Balcarres Haigh Yard	7·90	50·8	80·10	·634	57·67	44·13	80·0	8·23	401·32	398·3
	Cannel (Wigan)	7·70	48·3	76·80	·628	59·00	46·37	95·0	8·06	371·91	381·1
	Balcarres Lindsay	7·44	51·1	78·61	·650	53·83	43·83	70·0	7·58	380·18	431·5
	Balcarres Five-feet	7·21	49·0	79·11	·619	61·44	45·71	44·5	7·35	353·29	489·5
	Johnson and Wirthington's Sir John	6·32	51·6	81·73	·631	58·39	43·41	82·0	6.62	326·11	362·7
Newcastle Coals.	Andrew's House (Tanfield)	9·39	52·1	78·86	·660	51·36	42·99	..	9·80	489·21	351·2
	Newcastle Hartley	8·23	50·5	80·27	·629	58·95	44·35	78·5	8·65	415·61	308·0
	Hedley's Hartley	8·16	52·0	81·79	·635	57·28	43·07	85·5	8·71	424·32	300·8
	Bate's West Hartley	8·04	50·8	78·17	·649	53·87	44·13	69·5	8·26	408·43	406·8
	Buddle's West Hartley	7·82	50·6	77·11	·656	52·39	44·09	80·0	8·01	395·69	413·3
	Hastings Hartley	7·77	48·5	78·04	·621	60·90	46·18	75·5	7·96	376·84	404·5
	Carr's Hartley	7·71	47·8	78·23	·611	63·66	46·86	77·5	8·13	368·53	344·3
	Davison's West Hartley	7·61	47·7	78·36	·608	64·27	46·96	76·5	7·83	362·99	402·9
	North Percy Hartley	7·57	49·1	78·29	·627	59·45	45·62	60·0	7·72	371·68	423·5
	Haswell Coal Company's Steamboat Wallsend	7·48	49·5	79·36	·623	60·32	45·25	79·5	7·85	370·66	291·8
	Derwentwater's Hartley	7·42	50·4	78·79	·639	56·32	44·44	63·5	7·66	373·96	451·1
	Original Hartley	6·82	49·1	77·98	·629	58·81	45·62	80·0	6·98	334·86	428·4
	Cowpen and Sidney Hartley	6·79	47·9	78·67	·608	64·23	46·76	74·0	7·02	325·24	350·4
Scotch Coals.	Wellewood	8·24	52·6	79·78	·659	53·57	42·58	80·0	8·39	433·42	438·5
	Eglinton	7·37	52·0	79·84	·651	51·48	43·07	79·5	7·48	383·24	406·2
	Staveley (Derbyshire)	7·26	49·9	79·79	·625	59·90	44·88	88·5	7·40	362·27	466·2
	Conception Bay (Chili)	5·72	..	80·54	..	..	..	..	5·96	..	425·0
	Lyon's Patent Fuel	9·58	61·1	74·73	·817	22·30	36·66	..	9·77	585·33	409·1

The peculiar quality of the coals employed in the experiments is ascertained by chemical analysis. The character of the economic and chemical experiments differ essentially in one respect, viz., that while in the former many hundred weights are employed in the experiments, in the latter only a few grains are required. It is, therefore, essentially necessary to take precautions that these few grains represent the average state of the coal. In order to ensure this result, a large quantity of the coal is reduced to powder and is well mixed, by passing through sieves of various sizes. The larger fragments remaining on the wider meshes are reduced to powder, so as to enable them to pass through the finer sieves, and be completely mingled with the remainder. The quantity of coal to be examined is taken from this carefully averaged sample. It is found by experiment, that perfectly accordant results are obtained, when small quantities are operated upon, and that imperfect combustion, and therefore discordant numbers, always attend the use of large quantities. These analytical results are placed in Table II. In that table also will be found some valuable analyses

of coals from foreign stations, which have from time to time been sent to us from the Admiralty.

TABLE II.—Showing the Mean Composition of Average Samples of the Coals.

	Locality or Name of Coal.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
		A.	B.	C.	D.	E.	F.	G.	H.
Welsh Coals.	Thomas's Merthyr	1·30	90·12	4·33	1·00	0·85	2·02	1·68	86·53
	Nixon's Merthyr	1·31	90·27	4·12	0·63	1·20	2·53	1·25	79·11
	Hill's Plymouth Works	1·35	88·49	4·00	0·46	0·84	3·82	2·39	82·25
	Aberdare Co.'s Merthyr	1·31	88·28	4·24	1·66	0·91	1·65	3·26	85·83
	Gadly Nine-feet Seam	1·33	86·18	4·31	1·09	0·87	2·21	5·34	86·54
	Neath Abbey	1·31	89·04	5·05	1·07	1·60	..	3·55	61·42
	Gadly Four-feet Seam	1·32	88·56	4·79	0·88	1·21	..	4·88	88·23
	Llynvi	1·28	87·18	5·06	0·86	1·33	2·53	3·04	72·94
	Rock Vawr	1·29	77·98	4·39	0·57	0·96	8·55	7·55	62·50
Lancashire Coals.	Balcarres Arley	1·26	83·54	5·24	0.98	1·05	5·87	3·32	62·89
	Blackley Hurst	1·26	82·01	5·55	1·68	1·43	5·28	4·05	57·84
	Blackbrook Little Delf	1·26	82·70	5·55	1·48	1·07	4·89	4·31	58·48
	Rushy Park Mine	1·28	77·76	5·23	1·32	1·01	8·99	5·69	56·66
	Blackbrook Rushy Park	1·27	81·16	5·99	1·35	1·62	7·20	2·68	58·10
	Johnson and Wirthington's Rushy Park	1·28	79·50	5·15	1·21	2·71	9·24	2·19	57·52
	Laffak Rushy Park	1·35	80·47	5·72	1·27	1·39	8·33	2·82	56·26
	Balcarres Haigh Yard	1·28	82·26	5·47	1·25	1·48	5·64	3·90	66·09
	Cannel (Wigan)	1·23	79·23	6·08	1·18	1·43	7·24	4·84	60·33
	Balcarres Lindsay	1·26	83·90	5·66	1·40	1·51	5·53	2·00	57·84
	Balcarres Five-feet	1·26	74·21	5·03	0·77	2·09	8·69	9·21	55·90
	Johnson and Wirthington's Sir John	1·31	72·86	4·98	1·07	1·54	8·15	11·40	56·15
Newcastle Coals.	Andrew's House (Tanfield)	1·26	85·58	5·31	1·26	1·32	4·39	2·14	65·13
	Newcastle Hartley	1·29	81·81	5·50	1·28	1·69	2·58	7·14	64·61
	Hedley's Hartley	1·31	80·26	5·28	1·16	1·78	2·40	9·12	72·31
	Bate's West Hartley	1·25	80·61	5·26	1·52	1·85	6·51	4·25	..
	Buddle's West Hartley	1·23	80·75	5·04	1·46	1·04	7·86	3·85	..
	Hasting's Hartley	1·25	82·24	5·42	1·61	1·35	6·44	2·94	35·60
	Carr's Hartley	1·25	79·83	5·11	1·17	0·82	7·86	5·21	60·63
	Davison's West Hartley	1·25	83·26	5·31	1·72	1·38	2·50	5·84	59·49
	North Percy Hartley	1·25	80·03	5·08	0·98	0·78	9·91	3·22	57·18
	Haswell Coal Co.'s Steamboat Wallsend	1·27	83·71	5·30	1·06	1·21	2·79	5·93	61·38
	Derwentwater's Hartley	1·26	78·01	4·74	1·84	1·37	10·31	3·73	54·83
	Original Hartley	1·25	81·18	5·56	0·72	1·44	8·03	3·07	58·22
	Cowpen and Sidney Hartley	1·26	82·20	5·10	1·69	0·71	7·97	2·33	58·59
Scotch Coals.	Wellewood	1·27	81·36	6·28	1.53	1·57	6·37	2·89	59·15
	Eglinton	1·25	80·08	6·50	1·55	1·38	8·05	2·44	54·94
	Staveley (Derbyshire)	1·27	79·85	4·84	1·23	0·72	10·96	2·40	57·86
Foreign Coals.	Conception Bay (Chili)	1·29	70·55	5·76	0·95	1·98	13·24	7·52	43·63
	Sydney, N. S. W.	..	82·39	5·32	1·23	0·70	8·32	2·04	..
	Port Famine	..	64·18	5·33	0·50	1·03	22·75	6·21	..
	Chirique	..	38·98	4·01	0·58	6·14	13·38	36·91	..
	Laredo Bay	..	58·67	5·52	0·71	1·14	17·33	16·63	..
	Sandy Bay, No. 1 (Patagonia)	..	62·25	5·05	0·63	1·13	17·54	13·40	..
	,, No. 2 (Patagonia)	..	59·63	5·68	0·64	0·96	17·45	15·64	..
	Talcahnano Bay	..	70·71	6·44	1·08	0·94	13·95	6·92	..
	Vancouver's Island	..	66·93	5·32	1·02	2·20	8·70	15·83	..
	Colcurra Bay (Chili)	..	78·30	5·50	1·09	1·06	8·37	5·68	..
	Lyon's Patent Fuel	1·13	86·36	4·56	1·06	1·29	2·07	4·66	..

Another more simple means of identification, which it is convenient to record, is obtained by estimating what has been termed the calorific value of the coal. This depends upon the circumstance, that within certain limits of error, the calorific value of a coal may be expressed by the quantity of oxygen required to consume it. This amount is experimentally determined by the quantity of lead which the coal reduces when heated with an excess of litharge, that oxide yielding the amount of oxygen necessary for the combustion of the coal. Properly considered, all combustible matter should be viewed as

adding its increment to the calorific result, and as such should be allowed its value; but as the amount of sulphur in coals, although increasing the calorific unit, is objectionable in many respects, it may be considered advisable to correct the table for the quantity of lead reduced by it. This correction is not, but may, be very simply made for Table III. by the following formula $\frac{L - (s \times 0{\cdot}77)}{5}$ in which L is the quantity of grains of lead reduced by 5 grains of coal, s, the per centage of sulphur as shown in column E of Table II.

The correction has not been made, as it is thought better to give the actual result of experiment, and because the correction is within the errors of repeated experiments. In most cases, the error arising from iron pyrites is within 0·1 to 0·19 per cent. of the total lead found, and as this quantity is less than the difference between three successive experiments, it obviously falls within the limits of error, and may be safely rejected, so far as the practical result is concerned.

TABLE III.—Showing the Calorific Values of the Coals.

	Name of Coal.	Quantity of Lead Reduced by one part of Coal.	Oxygen Removed from Litharge by one part of Coal.
Welsh Coals.	Thomas's Merthyr	32·96	2·56
	Nixon's Merthyr	33·20	2·57
	Hill's Plymouth Work	34·06	2·64
	Aberdare Co.'s Merthyr	34·12	2·65
	Gadly Nine-feet Seam	34·16	2·65
	Neath Abbey	31·20	2·42
	Gadly Four-feet Seam	34·24	2·66
	Llynvi	32·24	2·50
	Rock Vawr	28·92	2·24
Lancashire Coals.	Balcarres Arley	29·40	2·28
	Blackley Hurst	29·58	2·29
	Blackbrook Little Delf	28·68	2·22
	Rushy Park Mine	28·98	2·25
	Blackbrook Rushy Park	30·36	2·35
	Johnson and Wirthington's Rushy Park	28·90	2·24
	Laffak Rushy Park	26·88	2·08
	Balcarres Haigh Yard	28·16	2·18
	Cannel (Wigan)	29·74	2·33
	Balcarres Lindsay	26·20	2·35
	Balcarres Five-feet	25·96	2·01
	Johnson and Wirthington's Sir John	23·80	1·84
Newcastle Coals.	Andrew's House (Tanfield)	31·06	2·41
	Newcastle Hartley	31·86	2·47
	Hedley's Hartley	30·36	2·35
	Bate's West Hartley	28·92	2·24
	Buddle's West Hartley	29·54	2·29
	Hasting's Hartley	28·56	2·21
	Carr's Hartley	30·90	2·40
	Davison's West Hartley	30·12	2·33
	North Percy Hartley	29·10	2·25
	Haswell Coal Co.'s Steamboat Walls-end	28·80	2·23
	Original Hartley	26·62	2·06
	Derwentwater's Hartley	29·10	2·25
	Cowpen and Sidney Hartley	28·66	2·22
Scotch Coals.	Wellewood	28·38	2.20
	Eglinton	24·32	1·88
	Staveley (Derbyshire)	28·08	2·18
	Conception Bay (Chili)	25·62	1·97
	Lyon's Patent Fuel	31·38	2·43

It may be desirable to state that the next Report will include the remainder of those coals which it is thought expedient to examine. The investigation continues to be conducted in the same manner as formerly, our own superin-

tendence being freely given as heretofore, and the actual practical experiments being confided to Mr. J. Arthur Phillips. Mr. How conducted the chemical analyses, until his removal to Edinburgh, after which they were undertaken by Mr. T. T. Philipps.

In acknowledging the kind and liberal support which has been extended to us by those desirous of promoting this inquiry, we would wish more especially to call attention to the disinterested and important aid afforded by Mr. Samuel Hocking, to whose great knowledge of Cornish boilers we are indebted for much valuable information, and for having personally superintended the setting of the boiler employed in these researches.

H. T. DE LA BECHE.
LYON PLAYFAIR.

APPENDIX.

ADMIRALTY COALS INVESTIGATION.

On the EVAPORATIVE POWERS of COALS, &c., by J. ARTHUR PHILLIPS.

THE following experiments have been conducted in all respects similarly to those described in the latter portion of the "First Report on the Coals Suited to the Steam Navy;" the water being evaporated at atmospheric pressure, and the results calculated by the formulæ there given.*

* The principal formulæ employed in these calculations are as follows:—

For the determination of the evaporative power of the coals, we have

$$\frac{(W - Eq + w - w')\,l + (W + w - w')\,t + wt' + (w' - w)\,t''}{Pl} = E'$$

in which W is the weight of water let down from the tanks during the experiment.

E = the coefficient of evaporative power of wood.

q = the weight of wood using for lighting the fire.

w = the weight of water (as found by the Table of Expansion) contained in the boiler at commencement of experiment.

w' = the weight of water in boiler at close of experiment.

l = the coefficient of the latent heat of steam.

t = the quantity of heat necessary to raise the water in tanks from its mean temperature to that at which it is evaporated.

t' = the quantity of heat necessary to raise the initial to the final temperature of the water in the boiler.

t'' = the quantity of heat necessary to raise water at the temperature of tanks to the final temperature of water in boiler.

P = the weight of coal consumed during experiment.

E' = the coefficient of the evaporative power of coal.

But when the initial is lower than the final temperature, the formula becomes

$$\frac{(W - Eq + w - w')\,l + Wt + wt' + (w' - w)\,t'''}{Pl} = E'$$

in which all the terms retain their original value except the last, in which t'' is replaced by t''', which is the quantity of heat necessary to raise the final temperature to that at which the water was evaporated, and must be regarded as having a negative value, whilst t' becomes positive.

The combustible matter in the cinder ash and soot has been estimated as described in the First Report, and the calculations made by the same formulæ, thus:—If Q be the weight of coal containing the same weight of combustible matter as the residua after combustion in the furnace, we have

$$\frac{(W - Eq + w - w')\,l + (W + w - w')\,t + wt' + (w' + w)\,t''}{(P - Q)\,l} = E''$$

and

$$\frac{(W - Eq + w - w')\,l + Wt + wt' + (w' - w)\,t'''}{(P - Q)\,l} = E'';$$

E'' being the corrected coefficient of the evaporative power of coal.

Let then w_1 = the weight of ashes after experiment,

" w_2 " cinder "

" w_3 " soot "

The weight of cinder is taken after the separation of the clinker.

Let r_1, r_2, r_3 be the respective per centages of combustible matter in the ash, cinder, and soot.

" Q the weight of coal containing the same weight of combustible matter,

" r the per centage of combustible matter as found in the coal by analysis.

Then $r\,Q = r_1 w_1 + r_2 w_2 + r_3 w_3$,

$$\therefore\ Q = \frac{r_1 w_1 + r_2 w_2 + r_3 w_3}{r}$$

TABLE I.—SHOWING the EXPANSION of WATER in the BOILER at different TEMPERATURES.

Temperature of Water, Fahr.	Ratio of Apparent to Real Weight.	Actual Weight of Water in Boiler when filled to Normal Point.	Difference between Actual and Apparent Weight.	Temperature of Water, Fahr.	Ratio of Apparent to Real Weight.	Actual Weight of Water in Boiler when filled to Normal Point.	Difference between Actual and Apparent Weight.
°		lbs.		°		lbs.	
70	1·0000	4730·000	0·000	170	0·9940	4701·620	28·380
80	0·9996	4728·108	1·892	180	0·9923	4693·579	36·421
90	0·9992	4726·216	3·784	190	0·9901	4683·173	46·827
100	0·9987	4723·950	6·050	200	0·9879	4672·767	57·233
110	0·9983	4721·960	8·040	202	0·9869	4668·037	61·963
120	0·9979	4719·097	10·903	204	0·9859	4663·307	66·693
130	0·9974	4717·795	12·205	206	0·9849	4658·577	71·423
140	0·9971	4715·283	14·717	208	0·9839	4653·847	76·153
150	0·9967	4714·012	15·988	210	0·9829	4649·117	80·883
160	0·9954	4708·242	21·758	212	0·9819	4644·387	85·613

TABLE No 2.

Air Thermometer Centigrade.	Mercurial Centigrade.	Number of Unities of Heat abandoned by one Pound of Water in descending from T to O°.	Air Thermometer Fahrenheit.	Mercurial Fahrenheit.	Number of Unities of Heat contained in One Pound of Water at T°.	Mean Specific Heat of Water between O° and T cent., or between 32° and T Fahrenheit.	Specific Heat of Water from T to T+dT.	Latent Heat of Vapour Saturated to the Temperature T.	
								Centigrade.	Fahrenheit.
°	°		°						
0	..	0·000	32	..	32·000	..	1·0000	606·5	1091·7
10	..	10·002	50	..	50·003	1·0002	1·0005	599·5	1079·1
20	..	20·010	68	..	68·018	1·0005	1·0012	592·6	1066·7
30	..	30·026	86	..	86·046	1·0009	1·0020	585·7	1054·2
40	..	40·051	104	..	104·091	1·0013	1·0030	578·7	1041·6
50	50·2	50·087	122	122·36	122·156	1·0017	1·0042	571·6	1028·9
60	..	60·137	140	..	140·246	1·0023	1·0056	564·7	1016·4
70	..	70·210	158	..	158·381	1·0030	1·0072	557·6	1003·7
80	..	80·282	176	..	176·507	1·0035	1·0089	550·6	990·1
90	..	90·381	194	..	194·685	1·0042	1·0109	543·5	978·3
100	100·0	100·500	212	212·0	212·900	1·0050	1·0130	536·5	965·7
110	..	110·641	230	..	231·153	1·0058	1·0153	529·4	952·9
120	..	120·806	248	..	249·450	1·0067	1·0177	522·3	940·1
130	..	130·997	266	..	267·794	1·0076	1·0204	515·1	927·2
140	..	141·215	284	..	286·187	1·0087	1·0232	508·0	914·4
150	150·0	151·462	302	302·0	304·632	1·0097	1·0262	500·7	901·2
160	..	161·741	320	..	323·133	1·0109	1·0294	493·6	888·5
170	..	172·052	338	..	341·693	1·0121	1·0328	486·2	875·1
180	..	182·398	356	..	360·316	1·0133	1·0364	479·0	862·2
190	..	192·779	374	..	379·002	1·0146	1·0401	471·6	848·9
200	200·0	203·200	392	392·0	397·760	1·0160	1·0440	464·3	835·7
210	..	213·660	410	..	416·588	1·0174	1·0481	456·8	822·2
220	..	224·162	428	..	435·480	1·0189	1·0524	449·4	808·9
230	..	234·708	446	..	454·474	1·0204	1·0568	441·9	795·4

TABLE No. 3.—CORRECTION for EXPANSION and CONTRACTION of WATER in the TANKS, taking 70° as the Normal Temperature.

Temperature Fahrenheit.	Actual Weight of an Unity of Water.	Temperature Fahrenheit.	Actual Weight of an Unity of Water.
°		°	
40	1·001464	62	1·000712
42	1·001451	64	1·000534
44	1·001439	66	1·000356
46	1·001426	68	1·000178
48	1·001414	70	1·000000
50	1·001401	72	·999763
52	1·001294	74	·999527
54	1·001196	76	·999290
56	1·001094	78	·999054
58	1·000992	80	·998818
60	1·000890		

Lyon's Patent Fuel (No. 1).

I HEREBY certify that the 333 bricks of Patent Fuel are a fair sample of Lyon's Steam Fuel, as made at his works, Swansea.—WM. JONES, *Agent to J. W. Lyon, Esq.*

This fuel, which is made of a mixture of pitch and coal dust, is manufactured into blocks having the following dimensions $9'' \times 9'' \times 5''$. Each of these masses weighs about 14 lbs., and has a mean specific gravity of 1·20. The bricks which were sent for the purposes of the investigation did not appear to be sufficiently pressed, many having become broken and almost reduced to powder during the transit from Swansea to London. Their shape is also less advantageous than that of some other varieties of patent fuel which have been experimented on. During our trials it was found to produce the best results when thrown on the fire in large lumps, as it then evolves less smoke than when used in smaller fragments with more frequent stoking. This method of treating it is, however, attended with the inconvenience that the gradual meeting of the large blocks has a tendency to choke the draught and thereby cut off from the burning mass the necessary supply of air. Whenever the fire was stoked, much smoke appeared at the chimney-top; but by careful management and constant attention, a good fire may be obtained from this fuel. During our trials but little soot was deposited in the flues, and little ash left on the bars; but a considerable quantity both of cinder and clinker was found at the termination of each experiment.

	February 2, 1st day.	February 3, 2nd day.	February 4, 3rd day.
Fire lighted	8 h. 30 m.	10h. 30m.	10 h. 10 m.
Steam up	9 h. 15 m.	11h. 10m.	11 h. 40 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	191°	191°	185°
Temperature of water in tanks	38°	40°	40°
Barometer	30·30 in.	30·42 in.	30·25 in.
Extremes of external thermometer	..	..	..
Extremes of internal thermometer	43°—50°	50°—61°	58°—61°
Dewpoint	40°	43°	43°
Area of damper open	112 in.	56 in.	84 in.
Weight of fuel consumed	476 lbs.	356 lbs.	323 lbs.
Weight of ashes left	10 lbs.	10 lbs.	9 lbs.
Per centage of combustible matter in ashes	29·7	23·5	29·0
Weight of cinder left	5 lbs.	8 lbs.	8 lbs.
Per centage of combustible matter in cinder	63·8	78·04	7·92
Weight of clinker in cinder*	10 lbs.	4 lbs.	6 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3720 lbs.	2830 lbs.	2860 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	9·17 lbs.	9·18 lbs.	10·11 lbs.
Weight of fuel per hour for 1 square foot of grate surface	11·9 lbs.	8·9 lbs.	9·22 lbs.
Duration of experiment	8 hrs.	8 hrs.	7 hrs.
Specific gravity of fuel	1·133	..	..
Mean weight of cubic foot of fuel	59·47 lbs.	..	..
Economic weight or space occupied by 1 ton	36·66 ft.	..	..
Cohesive power of fuel	..	..	..

* The weight of cinder is invariably taken after the separation of the clinker.
Note.—Final temperature on fourth morning, 175°.

Wellewood Coal.

I HEREBY certify that the six casks marked Nos. 1 and 2 contain a fair sample of the Wellewood Colliery steam-coals which were mined specially for the service of the "Admiralty Coals Investigation."—WALTER BROWN.

The mine from which these coals were extracted is situated in the parish of Dunfermline, in the county of Fife, at a distance of 5½ miles from the town of Charleston, which is the shipping port. Its current price is 8*s.* 6*d.* per ton rendered on board ship. It is at present chiefly used by shipping, and is described by the proprietor as the "best in the district for steam purposes." The coals experimented on were the produce of two different veins. No. 1 was raised at a depth of 82 fathoms from the surface, whilst No. 2 was extracted from a part of the mine which does not exceed half that depth. Both veins have a dip towards the north-west, and are worked by the "long-wall system." The overlying strata are composed of shale, but the subjacent rock, not having been pierced, nothing is yet known of its composition. The proprietor gives no information relative to the regularity of the seams, but states No. 1 is 3½ feet, and No. 2 4½ feet in thickness.

The specimens sent up for trial present the appearances of an extremely hard splint with lines of fracture parallel to the planes of deposition. Little difference was observed between the samples 1 and 2, except that the former contained less iron pyrites and evolved less smoke during combustion than the latter. It was remarked during the experiments, that these coals lighted readily and got up the steam rapidly, but emitted much smoke during the whole time of combustion. They do not, however, require much stoking, it being only necessary to push the heated coal from the dead plate on to the grate in order

to insure a good fire. These coals, when burnt, leave a white ash and but little clinker, which is easily detached from the bars. They do not coke on the dead plate, but yield much soot of a light description.

—	No. 1. — March 10, 1st day.	No. 1. — March 11, 2nd day.	No. 2. — March 13, 3rd day.
Fire lighted	8 h. 45 m.	8 h. 25 m.	9 h. 45 m.
Steam up	9 h. 30 m.	8 h. 40 m.	10 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	160°	209°	174°
Temperature of water in tanks	50°	46°	41°
Barometer	29·50 in.	28·90 in.	29·33 in.
Extremes of external thermometer	..	..	..
Extremes of internal thermometer	51°—56°	52°—56°	50°—56°
Dewpoint	38°	44°	45°
Area of damper open	84 in.	112 in.	84 in.
Weight of coals consumed	534 lbs.	556 lbs.	394 lbs.
Weight of ashes left	9 lbs.	13 lbs.	8 lbs.
Per centage of combustible matter in ashes	45·4	40·5	35·0
Weight of cinder left	7 lbs.	6 lbs.	5 lbs.
Per centage of combustible matter in cinder	97·7	92·8	41·8
Weight of clinker in cinder	6 lbs.	12 lbs.	1 lb.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3580 lbs.	4170 lbs.	2775 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·33 lbs.	8·35 lbs.	8·05 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·35 lbs.	13·9 lbs.	13·13 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·279	..	..
Mean weight of cubic foot of coal	52·6 lbs.	..	..
Economic weight or space occupied by 1 ton	42·58 ft.	..	..
Cohesive power of coal	80·0	..	..

Note.—Final temperature on fourth morning, 162°.

Eglinton Coal.

I HEREBY certify that the 12 boxes marked J. Arthur Phillips, Esq., contain a fair sample of the Eglinton coals which were mined specially for the service of the "Admiralty Coals Investigation."—A. KENNETH and Co., *Proprietors.*

This colliery is situated in the parish of Kilwinning to the north of Eglinton Castle, in the county of Ayr, and contains four seams. The main coal, which is 40 fathoms from the surface, and four feet in thickness, consists of two parts; the upper portion is two feet in thickness, and is composed of cubical coals, whilst the lower, which is a splint, is divided from the upper by a thin seam of fire clay. Next to the main coal, at a depth of 34 fathoms from the surface, is found the "stone coal" seam, which is 2 feet 6 inches in thickness, and, like the foregoing, divided into two parts by a band of clay. Two feet of the lower part of this seam are composed of splint, and 6 inches of the upper portion of cubical coals.

The Elle coal vein is found at a depth of 25 fathoms from the surface, and is also 2 feet 6 inches in thickness, 8 inches being splint, and the remainder cubical coals. The Ladyna, which is the last of these seams, and also the nearest the surface, has the same thickness as the two last mentioned, and produces both cubical and splint coals, although the former is found in the largest proportion. All these seams have an inclination of 1 in 12 towards the south-east, and are worked by the room and pillar method.

The distance of the mine from the shipping port Addrossan is six miles, and the present market price 7*s.* 4*d.* per ton. It is chiefly sent to Ireland. The specimen of this coal, which came to Putney College for the purposes of the investigation, was beautifully bright, with indications of a cubical fracture; it, however, contained small quantities of iron pyrites and white shaly matter.

This coal was found, during our experiments, to light easily, burn rapidly, and evolve much smoke; it also requires to be stoked, like a splint coal, and leaves a white ash, with little clinker and cinder. The clinker does not attack the bars.

—	March 16, 1st day.	March 17, 2nd day.	March 18, 3rd day.
Fire lighted	9 h. 45m	8 h. 15 m.	8 h. 10m.
Steam up	10h. 30m.	8 h. 40 m.	8 h. 40m.
Weight of wood used	10 lb.	10 lbs.	10 lbs.
Initial temperature of water in boiler	150°	208°	201°
Temperature of water in tanks	46°	46°	46°
Barometer	29·57 in.	29·43 in.	29·40 in.

	March 16, 1st day.	March 17, 2nd day.	March 18, 3rd day.
Extremes of external thermometer	..	..	..
Extremes of internal thermometer	52°—57°	54°—58°	..
Dewpoint	48°	46°	46°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	643 lbs.	436 lbs.	489 lbs.
Weight of ashes left	10 lbs.	13 lbs.	15 lbs.
Per centage of combustible matter in ashes	28·4	26·1	25·1
Weight of cinder left	8·5 lbs.	6 lbs.	5 lbs.
Per centage of combustible matter in cinder	84·0	65·1	77·3
Weight of clinker in cinder	2.75 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3610 lbs.	2820 lbs.	3320 lbs
Weight of water evaporated from 212° by 1 lb. of coal	7·08 lbs.	7·41 lbs.	7·62 lbs.
Weight of coals per hour for 1 square foot of grate surface	16·07 lbs.	10·90 lbs.	12.22 lbs.
Duration of experiment	8 hrs.	8 hrs.	8hrs.
Specific gravity of coal	1·257	..	..
Mean weight of cubic foot of coal	52·0 lbs.	..	..
Economic weight or space occupied by 1 ton	43·07 ft.	..	..
Cohesive power of coal	79·5	..	..

Note.—Final temperature on fourth morning, 178°.

Neath Abbey Coals.

I HEREBY certify that the casks sent to Putney College contain a fair sample of the Brynddwey coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JOSEPH J. PRICE, *Part Proprietor and Agent.*

The Neath Abbey Colliery is situate about 1½ mile from the port of Neath, and is worked on what is called the Brynddwey seam, which lies under the Drymma mountain. This vein has a regular thickness of 4 feet, with an inclination of 1½ inch in the yard towards the west, and is worked by level and inclined plane.

The coal, which is covered by hard rock, affording a good roof, lies on shale and fine clay, and is described by the proprietors as "non-bituminous and free burning;" they also state that the same seam is explored at Graigola, Parson's Graigola, Ynisymmon, and Wernddu, where large quantities of coal are extracted.

The specimen sent us for examination was very irregular in its structure, having no definite lines of stratification, but appeared an agglomeration of fragments rather than a series of regular deposits. When broken this coal yields fragments having the appearance of being rubbed on all their sides, and suggests the idea that at some period of its existence the vein must have been disturbed, and again cemented together by pressure.

Under the boiler it was found to light easily and burn freely, with the evolution of much smoke. It was, however found to swell on the bars, and thereby obstruct the draught, which requires the frequent use of the rake in order to keep up the fire.

At the close of the experiments rather large quantities of reddish ash remained, the amount of which was materially increased by the friable nature of the coals, which crumbled on the fire and fell through the bars. The amount of clinker was not very considerable, but that formed was found to adhere firmly to the bars, and not to be removed without difficulty.

	March 27, 1st day.	March 29, 2nd day.	March 30, 3rd day.
Fire lighted	9 h. 45 m.	8 h. 55 m.	12 h. 25 m.
Steam up	10 h. 45m.	9 h. 35 m.	1 h. 20 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	100°	165°	201°
Temperature of water in tanks	54°	58°	58°
Barometer	29·80 in.	29·87 in.	29·85 in.
Extremes of external thermometer	53°—56°	54°—59°	65°—60°
Extremes of internal thermometer	53°—58°	58°—65°	59°—63°
Dewpoint	46°	45°	55°
Area of damper open	84 in.	112 in.	56 in.
Weight of coals consumed	596 lbs.	589 lbs.	416 lbs.
Weight of ashes left	13 lbs.	13 lbs.	23 lbs.
Per centage of combustible matter in ashes	37·6	48·2	68·3
Weight of cinder left	9 lbs.	6 lbs.	9·5 lbs.
Per centage of combustible matter in cinder	62·5	85·9	89·7
Weight of clinker in cinder	8 lbs.	7 lbs.	3·75 lbs.
Average weight of soot in flues	none.	none.	none.
Per centage of combustible matter in soot	,,	,,	,,
Weight of water evaporated	4575 lbs.	4636 lbs.	3350 lbs.

	March 27, 1st day.	March 29, 2nd day.	March 30, 3rd day.
Weight of water evaporated from 212° by 1 lb. of coal	9·46 lbs.	9·43 lbs.	9·27 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·90 lbs.	14·72 lbs.	11.90 lbs.
Duration of experiment	8 hrs.	8 hrs.	7 hrs.
Specific gravity of coal	1·310	..	..
Mean weight of cubic foot of coal	58·3 lbs.	..	..
Economic weight or space occupied by 1 ton	37·77 ft.	..	..
Cohesive power of coal	50·0	..	..

Note.—Final temperature on fourth morning, 201°.

Blackbrook Rushy Park Coals.

I HEREBY certify that the seven boxes marked 1, 2, 3, 4, 5, 6, 7, contain a fair sample of the Blackbrook Rushy Park Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—DANIEL BROMILOW, *for the Firm of Bromilow Brothers and Southern.*

The mine from which this coal is extracted is situated at Rushy Park, Blackbrook, near the town of St. Helens, Lancashire.

This coal is raised from distances varying from 150 to 280 yards from the surface, and is considered "hot and free burning." The vein varies from 4 feet 6 inches to 5 feet in thickness, and is free from accident.

The subjacent and overlying strata are shale and white stone which, together with the vein itself, have an inclination of one yard in seven towards the S.E. The extraction is at present carried on by means of open bays and levels. Its current price varies from 6*s.* to 7*s.* per ton at the pit. Liverpool is its principal market, and is situated at a distance of about 30 miles by water from the colliery.

Large quantities of these coals are used for steam purposes both by the Government and other steamers belonging to the port of Liverpool.

The specimen of this coal which reached us for the purposes of the investigation was rather soft though brilliant, and evinced a tendency to divide itself into cubes, notwithstanding that the lines of cleavage were less distinctly marked than in many other varieties from the same district. There was also a nearly total absence of iron pyrites and shale, but a silky appearance often before referred to was very observable.

It was remarked during the progress of the experiments that these coals light easily, and get up the steam rapidly, but give off considerable quantities of smoke both on lighting and stirring the fire, although with careful stoking little smoke will appear at the chimney top. In order to avoid this the coals should be partially coked on the dead plate, and from thence pushed on to the fire, by which means it will, in a great measure, be remedied.

The quantity of ash is small, and that portion which falls through the bars may be easily burnt by being again thrown on the fire. The clinker is small in quantity, and attaches itself firmly to the fire-bars.

	April 7, 1st day.	April 8, 2nd day.	April 12, 3rd day.
Fire lighted	8 h. 35 m.	8 hr. 50 m.	9 hr. 15 m.
Steam up	8 h. 50 m.	9 h. 15 m.	9 hr. 35 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	196°	196°	201°
Temperature of water in tanks	56°	57°	56°
Barometer	29·54 in.	29·43 in.	29·43 in.
Extremes of external thermometer	41°—57°	42°—59°	41°—56°
Extremes of internal thermometer	56°—62°	59°—64°	60°—64°
Dewpoint	51°	53°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	609 lbs.	499 lbs.	489 lbs.
Weight of ashes left	9 lbs.	7 lbs.	12 lbs.
Per centage of combustible matter in ashes	76·9	92·3	85·9
Weight of cinder left	8 lbs.	6 lbs.	8 lbs.
Per centage of combustible matter in cinder	96·2	85·7	92·7
Weight of clinker in cinder	·5 lbs.	·5 lbs.	·5 lbs.
Average weight of soot in flues	·6 lbs.	·6 lbs.	·6 lbs.
Per centage of combustible matter in soot	78·9	..	..
Weight of water evaporated	4540 lbs.	3270 lbs.	3740 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·62 lbs.	7·55 lbs.	7·89 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·22 lbs.	12·47 lbs.	12·45 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·276	..	..
Mean weight of cubic foot of coal	55·3 lbs.	..	..
Economic weight or space occupied by 1 ton	40·50 ft.	..	..
Cohesive power of coal	80·5	..	..

Note.—Final temperature on fourth morning, 202°.

Blackbrook Little Delf Coals.

I HEREBY certify that the six casks marked Nos. 8, 9, 10, 11, 12, and 13 contain a fair sample of the Blackbrook Little Delf Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—DAVID BROMILOW, *for the Firm of Bromilow Brothers and Southern.*

This colliery is situated at Little Delf Blackbrook, near St. Helen's, Lancashire; its present depth from the surface is 170 yards. The coals are extracted by means of levels and open bays from a regular vein of 3 feet 6 inches in thickness, which has a dip of 1 in 5 towards the south-east. The subjacent and overlying strata consist of stone and shale, and the coals are described as "clear and free burning." The price at the pit's mouth varies from 6*s.* to 7*s.* per ton, but by far the larger portion is sold at Liverpool, which by water, is 32 miles distant from the mine. The proprietors state that, when mixed with their Rushy Park coal it forms good fuel for steam purposes. The sample which came into our hands very nearly resembles that last described, except that it contained large quantities of a white substance which is found interposed between the lines of cleavage and more particularly in those which are parallel to the lines of stratification.

This coal is also less firm than the last described, and has the lines of stratification more regularly and clearly marked.

During the practical experiments no distinct difference between this and the Blackbrook Rushy Park coal was observed, except that of the two the Little Delf appeared the more smoky.

—	April 18, 1st day.	April 19, 2nd day.	April 20, 3rd day.
Fire lighted	9 h. 40 m.	8 h. 30 m.	9 h. 45 m.
Steam up	10 h. 5 m.	9 h. 0 m.	10 h. 30m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	204°	205°	145°
Temperature of water in tanks	56°	49°	54°
Barometer	29·54 in.	29·43 in.	29·61 in.
Extremes of external thermometer.	36°—49°	..	45°—58°
Extremes of internal thermometer.	57°—61°	57°—59°	55°—62°
Dewpoint	52°	52·5°	53°
Area of Damper open	112 in.	56 in.	84 in.
Weight of coals consumed	565 lbs.	419 lbs.	460 lbs.
Weight of ashes left	10 lbs.	10 lbs.	17 lbs.
Per centage of combustible matter in ashes	75·6	92·7	88·6
Weight of cinder left	5 lbs.	6 lbs.	4 lbs.
Per centage of combustible matter in cinder	81·0	92·3	93·2
Weight of clinker in cinder	None.	..	..
Average weight of soot in flues	·6 lbs.	·6 lbs.	·6 lbs.
Per centage of combustible matter in soot	77·2	..	..
Weight of water evaporated	4190 lbs.	3230 lbs.	3150 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·57 lbs.	8·13 lbs.	8·17 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·12 lbs.	10·47 lbs.	12·0 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·263	..	..
Mean weight of cubic foot of coal	51·0 lbs.	..	..
Economic weight or space occupied by 1 ton	43·92 ft.	..	..
Cohesive power of coal	61·5	..	..

Note.—Final temperature on fourth morning, 194°.

Lyon's Patent Fuel.—Specimens 2 and 3.

These specimens were sent up for trial as being supposed to be an improvement on that previously experimented on, inasmuch as No. 2 contained less pitch than the former sample, and in No. 3 had been incorporated one-seventh part of its weight of powdered anthracite.

In general appearance this fuel resembled in every respect that tested February 2, 3, and 4, 1848.

Its behaviour under the boiler was also precisely similar, except that No. 3 left a rather larger amount of ash, occasioned by the burning away of the other constituents of the fuel, whilst a certain portion of the anthracite remained unconsumed.

The results of the practical trials will be found in the following table:—

	April 25, 1st day.	April 26, 2nd day.
Fire lighted	8 h. 55 m.	9 h. 40 m.
Steam up	9 h. 40 m.	10 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.
Initial temperature of water in boiler	203°	209°
Temperature of water in tanks	50°	54°
Barometer	29·85 in.	29·9 in.
Extremes of external thermometer	37°—50°	..
Extremes of internal thermometer	54°—61°	59°—63°
Dewpoint	45°	44°
Area of damper open	140 in.	140 in.
Weight of fuel consumed	446 lbs.	556 lbs.
Weight of ashes left	10 lbs.	11 lbs.
Per centage of combustible matter in ashes	..	..
Weight of cinder left	6 lbs.	13 lbs.
Per centage of combustible matter in cinder	..	..
Weight of clinker in cinder	6·4 lbs.	10 lbs.
Average weight of soot in flues	..	.
Per centage of combustible matter in soot	..	..
Weight of water evaporated	3640 lbs.	4460 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	9·57 lbs.	9·29 lbs
Weight of fuel per hour for one square foot of grate surface	11·15 lbs.	13·9 lbs.
Duration of experiment	8 hrs.	8 hrs.
Specific gravity of fuel	..	..
Mean weight of cubic foot of fuel	63·05 lbs.	..
Economic weight or space occupied by one ton	..	..
Cohesive power of fuel	..	..

Note.—Final temperature on third morning, 206°.

Blackley Hurst Coals.

I HEREBY certify that the six hogsheads marked S. S. B. H. contain a fair sample of coals from the Blackleyhurst Mines, which were mined specially for the service of the "Admiralty Coals Investigation."—SAMUEL STOCK, *Proprietor.*

Blackleyhurst is situated in the township of Billinge, in the parish and near the town of Wigan. Two seams are at present worked in this colliery, the one called the "Four Foot Vein," is mined at a distance of 60 yards from the surface, whilst the second, or "Three Foot Seam," has been followed to the depth of 140 yards. The average thickness of the former is 3 feet 10½ inches, whilst the Three Foot Vein is usually an inch less in thickness than its name implies. Both deposits are tolerably regular, and have each a dip of 20° to the south-east. The subjacent and overlying strata consist of "warren earth, black and blue shale, and bass." This coal is described by the proprietor as "clean and durable;" he also adds that it has been largely used by the Scotch and Irish steam-packets, and that the mixed produce of the two veins formed during two years and a-half, the supply of the Halifax and Boston Mail steam-ships. It has also been employed for the manufacture of gas.

This coal in appearance resembles the Blackbrook Rushy Park; but contains in large quantities the white shaly substance before referred to.

We observed during the experiments that this coal is slightly bituminous and rather fragile, yielding much smoke and depositing a considerable amount of soot. Little ash and clinker were, however, left, the latter being of reddish colour and very hard.

	April 27, 1st day.	April 28, 2nd day.	May 24, 3rd day.
Fire lighted	9 h. 25 m.	9 h. 20 m.	9 h. 40 m.
Steam up	9 h. 45 m.	9 h. 45 m.	10 h. 20m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	206°	165°
Temperature of water in tanks	50°	50°	68°
Barometer	29·90 in.	29·67 in.	30·30 in.
Extremes of external thermometer	38°—55°	35°—54°	..
Extremes of internal thermometer	59°—62°	56°—62°	51°—70°
Dewpoint	47°	49°	55°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	646 lbs.	464 lbs.	499 lbs.
Weight of ashes left	8 lbs.	16·5 lbs.	14 lbs.
Per centage of combustible matter in ashes	50·7	60·0	70·0
Weight of cinder left	5 lbs.	incl. in ash	8 lbs.
Per centage of combustible matter in cinder	89·7	..	79·4
Weight of clinker in cinder	7 lbs.	1·5 lbs.	0·27 lbs.
Average weight of soot in flues	1·9 lbs.	1·9 lbs.	1·9 lbs.
Per centage of combustible matter in soot	85·0	..	..
Weight of water evaporated	4830 lbs.	3550 lbs.	3640 lbs.

—	April 27, 1st day.	April 28, 2nd day.	May 24, 3rd day.
Weight of water evaporated from 212° by 1 lb. of coal	8·69 lbs.	8·88 lbs.	8·87 lbs.
Weight of coals per hour for 1 square foot of grate surface	16·15 lbs.	11·60 lbs.	12·47 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·260	..	..
Mean weight of cubic foot of coal	48·0 lbs.	..	..
Economic weight or space occupied by 1 ton	46·66 ft.	..	..
Cohesive power of coal	65·0	..	..

Note.—Final temperature on third morning, 206°; final temperature on fourth morning, 208°.

Johnson and Wirthington's Sir John Coals.

I HEREBY certify that the two casks marked S. J. contain a fair sample of the Sir John Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CHARLES WILLIAMS, *Agent.*

This coal, like the following, is raised in the township of Parr, near St. Helen's. The colliery is not, however, so deep as the Rushy Park, the coals being extracted from a depth of about 100 yards from the surface. The vein is 3 feet 3 inches in thickness, but is divided in the middle by a thin band of shale. The overlying and subjacent strata consist of sand, marl, flag, and stone coal of different kinds, though not of sufficient importance to pay for extraction. The vein has an inclination of one in six towards the north, and is worked by the long-wall system. This coal is described by the proprietors as "stubborn burning, and requiring a strong draught." Its shipping port is Liverpool, from whence the colliery is about 12 miles distant by land and 30 by water.

The produce of this mine is chiefly used for furnace purposes, particularly by the glass-houses in the immediate neighbourhood, where it appears to have given satisfaction. The present current price is 6*s.* at the colliery, and 9*s.* at Liverpool.

It was observed during the experiments that these coals are lighted with difficulty, and require a very strong draught in order to keep up the combustion.

The fire-bars also became much choked towards the close of the day by the accumulated ash and clinker, of which considerable quantities remained at the end of each experiment.

—	May 25, 1st day.	May 26, 2nd day.	May 27, 3rd day.
Fire lighted	9 h. 0 m.	9 h. 20 m.	8 h. 30 m.
Steam up	9 h. 20 m.	9 h. 55 m.	8 h. 40 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	208°	210°
Temperature of water in tanks	68°	70°	70°
Barometer	30·2 in.	30·15 in.	30·17 in.
Extremes of external thermometer	52°—70°	57°—76°	..
Extremes of internal thermometer	65°—72°	68°—77°	66°—76°
Dewpoint	54°	55°	55°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	585 lbs.	392 lbs.	570 lbs.
Weight of ashes left	17 lbs.	26 lbs.	31 lbs.
Per centage of combustible matter in ashes	18·8	31·7	30·9
Weight of cinder left	16 lbs.	16 lbs.	16 lbs.
Per centage of combustible matter in cinder	88·1	87·03	87·5
Weight of clinker in cinder	14 lbs.	2·75 lbs.	7 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	81·8	..	..
Weight of water evaporated	3220 lbs.	2240 lbs.	3245 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	6·27 lbs.	6·48 lbs.	6·20 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·62 lbs.	9·80	14·25 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·310	..	..
Mean weight of cubic foot of coal	51·66 lbs.	..	..
Economic weight, or space occupied by one ton	43·41 ft.	..	..
Cohesive power of coal	82·0	..	..

Note.—Final temperature on fourth morning, 185°.

Johnson and Wirthington's Rushy Park.

I HEREBY certify that the two casks marked R. P. contain a fair sample of the Rushy Park steam-coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CHARLES WILLIAMS, *Agent.*

The Rushy Park colliery is situate in the township of Parr, near St. Helen's, Lancashire. The vein from which the coals are extracted is 4 feet 8 inches in thickness, and very regular, with a dip of one in seven from north to south. The overlying and subjacent strata consist of sand, marl, and black band, with various coal-seams of inferior quality.

The coals are worked at a depth of 300 yards from the surface, by means of walls, and are described by the agent as "hot and swift." They are principally sent to Liverpool, where they are employed for steam purposes. The distance of the mine from the shipping port is by land 12 miles, and 30 by water. The specimen of this coal which was experimented on at Putney College was extremely brilliant, and had well-defined and regular lines of deposition, between which occur large quantities of a white substance resembling sulphate barytes. As the composition of this matter might materially affect the quality of the coal, it was thought of interest to determine its constituents, which were found to be as follows:—

ANALYSIS.

Carbonate of iron . .	41·51
,, lime . .	42·81
Sulphate of lime . . .	1·79
Silica	·29
Magnesia . . .	trace
Water	13·42
Total . . .	99·82

It was ascertained during the trials made of this coal that it lights easily and burns clearly, blowing off much steam; but this, like all others from the same district, evolves much smoke, both on lighting and stirring the fire; it however produces but little clinker or ash, and appears to contain little or no iron pyrites.

—	May 29, 1st day.	May 30, 2nd day.	May 31, 3rd day.
Fire lighted	9 h. 45 m.	8 h. 50 m.	9 h. 0 m.
Steam up	10 h. 20 m.	9 h. 0 m.	9 h. 20 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	185°	209°	202°
Temperature of water in tanks	70°	68°	66°
Barometer	30·05 in.	30·17 in.	30·0 in.
Extremes of external thermometer	..	48°—70°	47°—70°
Extremes of internal thermometer	68°—75°	69°—74°	69°—74°
Dewpoint	45°	46°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	577 lbs.	436 lbs.	553 lbs.
Weight of ashes left	12 lbs.	12 lbs.	9 lbs.
Per centage of combustible matter in ashes	30·8	47·7	49·5
Weight of cinder left	7 lbs.	3 lbs.	8 lbs.
Per centage of combustible matter in cinder	84·6	78·5	75·9
Weight of clinker in cinder	2 lbs.	1·8 lbs.	2·25 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	72·0	..	..
Weight of water evaporated	4210 lbs.	3040 lbs.	3660 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·59 lbs.	7·83 lbs.	7.62 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·42 lbs.	14·4 lbs.	13·82 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·284	..	..
Mean weight of cubic foot of coal	50·0 lbs.	..	..
Economic weight, or space occupied by 1 ton	44·80 ft.	..	..
Cohesive power of coal	69·0	..	..

Note.—Final temperature on fourth morning, 206°.

LAFFAK RUSHY PARK COALS.

I HEREBY certify that the five casks marked J contain a fair sample of the Laffak Rushy Park Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JOHN and THOMAS JOHNSON, *Proprietors.*

The Laffak Colliery is situated in the township of Parr, two miles north-east of the town of St. Helens, in the county of Lancashire. The coals are raised at a distance from the surface varying from 150 to 400 yards, and are extracted from what is called the Rushy Park Vein, which is regular and 4 feet 6 inches in thickness, with an inclination of one in six towards the S. S. E. The overlying and subjacent strata are strong blue flag, white rock, and blue bass. The coals are extracted by means of levels cut to the extent of the boundary, and then worked back by means of walls and bays.

The Sankey Canal, which is only 600 yards distant from the mine, affords an easy means of communicating with the Mersey at Runcorn, from which place it is conveyed by water to Liverpool, where it finds its market. The price at the pit's mouth is for screened coals 7*s.* 6*d.* per ton, to which must be added the expenses of shipping, which are light. Three pits or shafts have already been sunk on the "Rushy Park Vein, and by means of the powerful engines on the mine, 500 tons of coals may be daily extracted."

The specimen which was sent up for the purposes of the "Admiralty Coals Investigation" was hard and brilliant, occasionally presenting a conchoidal fracture, although it

more generally manifested a tendency to divide itself into cubes. The lines of deposition were but indistinctly marked, and little iron pyrites was observed.

This coal also appears to be very free from the white shaly substance to which we have before referred, and which materially increases the quantity of clinker formed. Under the boiler it was found to light easily, burn clearly, and produce but little clinker; it has, however, the disadvantage of evolving much smoke, particularly after charging or stirring the fire.

	June 1, 1st day.	June 2, 2nd day.	June 3, 3rd day.
Fire lighted	9 h. 10 m.	9 h. 30 m.	9 h. 30 m.
Steam up	9 h. 35 m.	9 h 50 m.	9 h. 50 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	200°	202°
Temperature of water in tanks	67°	62°	64°
Barometer	29·88 in.	29·40 in.	29·37 in.
Extremes of external thermometer	51°—65°	46°—66°	52°—65°
Extremes of internal thermometer	62°—70°	66°—71°	66°—72°
Dewpoint	50°	52°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	572 lb.	396 lbs.	511 lbs.
Weight of ashes left	10 lbs.	10 lbs.	11 lbs.
Percentage of combustible matter in ashes	43·9	52·06	47·3
Weight of cinder left	7 lbs.	7·3 lbs.	7·25 lbs.
Percentage of combustible matter in cinder	89·4	92·7	73·9
Weight of clinker in cinder	2 lbs.	0·6 lbs.	0·7 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Percentage of combustible matter in soot	81·0	..	..
Weight of water evaporated	3870 lbs.	2810 lbs.	3760 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·65	8·13	8·17
Weight of coals per hour for 1 square foot of grate surface	14·30 lbs.	9·90 lbs.	12·77 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·351	..	
Mean weight of cubic foot of coal	52·66 lbs.	..	
Economic weight or space occupied by 1 ton	42·58 ft.	..	
Cohesive power of coal	75·5	..	..

Note.—Final temperature on fourth morning, 180°.

Rushy Park Mine Coals.

I HEREBY certify that the four casks marked J. A. Phillips, Esq., contain a fair sample of the Rushy Park Mine coals, which were mined specially for the service of the "Admiralty Coals Investigation."—ROBERT ROBINSON, Jun., *for Bourne and Robinson.*

The Rushy Park Mine is situated at Broad Oak, near St. Helens, Lancashire, and is worked at a depth of 300 yards from the surface, where the seam is 4 feet 8 inches in thickness, with a regular dip of 1 in 5 towards the south-east.

The shipping ports are Runcorn and Liverpool, from the former of which places it is distant eight, and from the latter twelve miles. The present current price is 7*s.* per ton. They are described by the owners as "good bright coals, much liked for steam-packet purposes." They also further add, "We are now serving the Drogheda Steam-Packet Company, and the Liverpool Steam-Tug Company with the above coals, which give great satisfaction."

The sample which was sent us for experiment differed little in appearance from other specimens from the same neighbourhood, except that it was perhaps rather brighter, and almost entirely free from iron pyrites, though it contained a considerable amount of the white shaly matter so frequently mentioned in former parts of this Report. We remarked during the progress of the experiments that this coal lights easily, and blows off a considerable amount of steam; it also makes a clear fire, which leaves but little ash and clinker, the former being of a reddish brown, and the latter of a very dark colour, approaching to black. Considerable quantities of a greyish smoke was evolved during the experiments.

	June 5, 1st day.	June 6, 2nd day.	June 7, 3rd day.
Fire lighted	10 h. 15 m.	9 h. 30 m.	9 h. 25 m.
Steam up	10 h. 45 m.	9 h. 55 m.	9 h. 40 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	180°	194°	204°
Temperature of water in tanks	68°	66°	66°
Barometer	29·80 in.	29·92 in.	29·94 in.
Extremes of external thermometer	49°—67°	50°—69°	52°—66°
Extremes of internal thermometer	66°—72°	68°—72°	68°—72°

	June 5, 1st day.	June 6, 2nd day.	June 7, 3rd day.
Dewpoint	52°	47°	53°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	586 lbs.	399 lbs.	472 lbs.
Weight of ashes left	7 lbs.	9 lbs.	8 lbs.
Per centage of combustible matter in ashes	51·4	85·4	85·4
Weight of cinder left	4 lbs.	11 lbs.	5 lbs.
Per centage of combustible matter in cinder	97·0	97·1	84·0
Weight of clinker in cinder	1 lbs.	0·5 lbs.	0·25 lbs.
Average weight of soot in flues	0·5 lbs.	0·5 lbs.	0·5 lbs.
Per centage of combustible matter in soot	85·5	..	..
Weight of water evaporated	3950 lbs.	2700 lbs.	3410 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·84 lbs.	8·12 lbs.	8·29 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·65 lbs.	9·92 lbs.	11·80 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·283	..	..
Mean weight of cubic foot of coal	47·0 lbs.	..	..
Economic weight or space occupied by 1 ton	47·65 ft.	..	..
Cohesive power of coal	67·0	..	..

Note.—Final temperature on fourth morning, 206°.

Coal from the Llynvi Ironworks.

I HEREBY certify that the five casks marked 1, 2, 3, 4, 5, contain a fair sample of the Llynvi Iron Company's coal, which was mined specially for the service of the "Admiralty Coals Investigation.—CHARLES BOWINS, *Resident Director.*

The five casks sent up for trial were the produce of five different seams occurring in the various mines belonging to the above Company.

As, however, the quantity of each coal sent to Putney for trial was not sufficient for a series of experiments, they were all mixed together, and afterwards tested in the usual way.

The coals contained in cask No. 1 were extracted from the Four-foot Vein Level, situated at Duffryn, and belonging to the Llynvi Iron Company.

This vein is 4 feet in thickness, is described as regular, and is worked at a depth of 80 yards from the surface. The coal is extracted by "pillar and stall," and is spoken of by the agent as "quick burning, and containing little ash." The specimens contained in Nos. 2 and 4 were the produce of the Nant y Crynwydd Mine, where the coal is extracted near the surface. No. 2 being wrought at a depth of 12 yards, and No. 4 of 14 yards. The specimen No. 2 is the produce of the "Furnace Vein," which is regular, and 12 feet in thickness. No. 4 was extracted from the "Seven-foot Seam," which is also regular, and 7 feet in thickness. The former seam is worked by "patch," and the latter by "pillar and stalls." The samples 3 and 5 were extracted from the Cocgnant Mines; the former at a depth of 40 yards, and the latter at a depth of 50 yards from the surface. No. 3 is the produce of the Yard Vein, which is 3 feet in thickness, and tolerably regular; whilst No. 5 was raised from the Caedafid Level, and is a slow-burning coal, leaving considerable quantities of ash. The thickness of this seam is 4 feet 6 inches, with an inclination towards the south-east. The specimens of these coals sent to Putney for the service of the "Admiralty Coals Investigation" were rather friable, but generally bright and clean in their appearance, with the exception of No. 2, which appeared from some cause to have been partially coked previous to its extraction from the mine.

It was observed during the progress of the experiments that these coals burn steadily, and give off but little smoke. The ash produced is of a whitish colour, and that portion which falls through the bars is generally so far consumed as to render its being again thrown on the fire unnecessary. The quantities of ash, clinker, and cinder, were also found to be rather considerable; but the clinker being of that porous kind which does not attach itself to the bars, its amount was not found to materially affect the combution of the coals.

	June 8, 1st day.	June 9, 2nd day.	June 10, 3rd day.
Fire lighted	9 h. 30 m.	9 h. 15 m.	9 h. 0 m.
Steam up	9 h. 55 m.	9 h. 50 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	204°	197°
Temperature of water in tanks	64°	64°	60°
Barometer	29·82 in.	29·83 in.	29·7 in.
Extremes of external thermometer	49°—70°	55°—67°	55°—68°
Extremes of internal thermometer	68°—73°	65°—71°	66°—70°
Dewpoint	52°	48°	57°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	423 lbs.	328 lbs.	428 lbs.
Weight of ashes left	20 lbs.	11 lbs.	13 lbs.

—	June 8, 1st day.	June 9, 2nd day.	June 10, 3rd day.
Per centage of combustible matter in ashes	32·0	39·6	22·7
Weight of cinder left	13 lbs.	13 lbs.	18 lbs.
Per centage of combustible matter in cinder	79·0	81·1	72·7
Weight of clinker in cinder	8 lbs.	4 lbs.	7 lbs.
Average weight of soot in flues	·5 lbs.	·5 lbs.	·5 lbs.
Per centage of combustible matter in soot	69·5	..	..
Weight of water evaporated	3560 lbs.	2590 lbs.	3440 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·61 lbs.	8·89 lbs.	9·08 lbs.
Weight of coals per hour for 1 square foot of grate surface	10·5 lbs.	8·2 lbs.	10·7 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·288	..	..
Mean weight of cubic foot of coal	53·33 lbs.	..	..
Economic weight or space occupied by 1 ton	42·02 ft.	..	..
Cohesive power of coal	..	..	..

Note.—Final temperature on fourth morning, 185°.

Rock Vawr Coal.

I HEREBY certify that the four casks marked R. V., 1, 2, 3, 4, contain a fair sample of the Rock Vawr Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—ROBERT LINDSAY, *for Vivian and Sons, Proprietors.*

The Rock Vawr Colliery is situated in the Brombill Valley, parish of Margam, Glamorganshire, and is worked at a depth of 300 feet from the surface.

The vein is regular, and 3½ feet in thickness, with a dip of 3½ inches in the yard, 24° east of north. The subjacent strata are composed of rock, and the overlying of hard shale, having the same inclination as the vein itself. The mine is worked by cross-headings and stalls, and the coals are described as "free burning and slightly bituminous." The principal markets are Cornwall and Ireland; besides which, large quantities are used for the smelting of copper ores, and for steam-vessels. This mine is two miles and a quarter from the shipping port, which is Swansea, where its current price is 8*s.* 6*d.* per ton. The specimen of this coal, sent to Putney for the purpose of examination, was rather soft, but bright in its fracture, and contained considerable traces of iron pyrites, but none of the shaly matter mentioned as occurring in the Lancashire coals. During our experiments this coal was found to light easily, and afford a good fire, without much smoke; but at the close of the operations, considerable portions of ash, cinder, and clinker remained, particularly of the latter, which had fused, and adhered rather firmly to the bars.

—	June 12, 1st day.	June 13, 2nd day.	June 14, 3rd day.
Fire lighted	9 h. 15 m.	9 h. 0 m.	8 h. 45 m.
Steam up	9h. 50 m.	9 h. 15 m.	9 h. 5 m.
Weight of wood used	10 lbs.	10 lbs	10 lbs.
Initial temperature of water in boiler	185°	202°	208°
Temperature of water in tanks	64°	64°	65°
Barometer	29·67 in.	28·83 in.	30·03 in.
Extremes of external thermometer	56°—67°	47°—62°	53°—70°
Extremes of internal thermometer	66°—71°	66°—71°	68°—73°
Dewpoint	57°	51°	56°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	594 lbs.	403 lbs.	447 lbs.
Weight of ashes left	9 lbs.	9 lbs.	9 lbs.
Per centage of combustible matter in ashes	17·0	15·8	16·0
Weight of cinder left	13 lbs.	13 lbs.	8 lbs.
Per centage of combustible matter in cinder	80·8	89·7	84·9
Weight of clinker in cinder	13 lbs.	4·5 lbs.	7 lbs.
Average weight of soot in flues	·6 lbs.	·6 lbs.	·6 lbs.
Per centage of combustible matter in soot	85·0	..	..
Weight of water evaporated	3630 lbs.	2700 lbs.	3210 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·18 lbs.	7·76 lbs.	8·11 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·85 lbs.	10·07 lbs.	10·17 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·292	..	..
Mean weight of cubic foot of coal	55·0 lbs.	..	..
Economic weight or space occupied by 1 ton	40·72 ft.	..	..
Cohesive power of coal	65·5	..	..

Note.—Final temperature on fourth morning, 202°.

Newcastle Hartley Coals.

I hereby certify that the 34 casks marked No. 1 C. 34, contain a fair sample of the Newcastle Hartley steam coals, which were mined specially for the service of the "Admiralty Coals Investigation."—Edmund Latimer, *Proprietor.*

This coal is raised from the "Low Main Seam," and is extracted by the Spital Tongues Pit, within the borough of Newcastle-upon-Tyne.

The vein is worked to a depth of 48 fathoms, and varies from 4½ to 5 feet in thickness. It is mined by board and pillar, the aid of gunpowder being constantly required. The vein dips ½ an inch in the yard towards the south-east, and is, on the whole, tolerably regular. The overlying strata are composed of what is locally called "blue metal stone," and the subjacent of "grey metal stone," and impure coal. It is described as "bituminous, and free from sulphur, but throwing off considerable quantities of smoke during combustion." The current price is 7*s.* per ton at the colliery, which is two miles and a quarter from the shipping port. The proprietor, speaking of this colliery, says, it was established in 1835 by Messrs. Porter and Latimer, under a lease from the Corporation of Newcastle. The royalty extends under the town moor, which has a surface of 1025 acres. The vend during the year 1847, amounted to 87,113 tons, of which 59,055 were used within the port for steam and other manufacturing purposes; 11,083 were sent coastwise, principally to London and Scotland; and, finally, 17,005 tons were exported to the foreign markets, chiefly Spain and the Baltic.

We remarked during our experiments on this coal, that it lights with difficulty, and requires a strong draught to carry on combustion economically; and that even then a large quantity of smoke is evolved. The ashes left are of a whitish colour, and in considerable quantity. The clinker is brittle, and does not adhere to the bars.

	June 15, 1st day.	June 16, 2nd day.	June 17, 3rd day.
Fire lighted	10 h. 15 m.	9 h. 35 m.	10 h. 30 m.
Steam up	10 h. 40 m.	10 h. 15 m.	10 h. 50 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	202°	196°	208°
Temperature of water in tanks	69°	71°	70°
Barometer	29·87 in.	30·0 in.	29·89 in.
Extremes of external thermometer	60°—75°	60°—78°	56°—69°
Extremes of internal thermometer	69°—77°	72°—79°	65°—76°
Dewpoint	57°	59°	59°
Area of damper open	112 in.	98 in.	81 in.
Weight of coals consumed	339 lbs.	418 lbs.	296 lbs.
Weight of ashes left	11 lbs.	11 lbs.	11 lbs.
Per centage of combustible matter in ashes	23·2	28·7	48·7
Weight of cinder left	10·5 lbs.	14 lbs.	19·5 lbs.
Per centage of combustible matter in cinder	93·4	78·0	90·0
Weight of clinker in cinder	2·5 lb.	3 lbs.	2·5 lbs.
Average weight of soot in flues	·8 lbs.	·8 lbs.	·8 lbs.
Per centage of combustible matter in soot	70·4	..	..
Weight of water evaporated	2480 lbs.	3060 lbs.	2160 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·04 lbs.	8·52 lbs.	8·15 lbs.
Weight of coals per hour for 1 square foot of grate surface	8·47 lbs.	9·28 lbs.	7·4 lbs.
Duration of experiment	8 hrs.	9 hrs.	8 hrs.
Specific gravity of coal	1·293	..	..
Mean weight of cubic foot of coal	50·5 lbs.	..	..
Economic weight or space occupied by 1 ton	44·35 ft.	..	..
Cohesive power of coal	78·5	..	..

Note.—Final temperature on fourth morning, 185°.

Balcarres Lindsay Coal.

I hereby certify that the five casks marked respectively $\frac{L}{1}$, $\frac{L}{2}$, $\frac{L}{3}$, $\frac{L}{4}$, $\frac{L}{5}$, contain a fair sample of the Lindsay Mine Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—William Peace, *Agent.*

This mine, which is the property of the Earl of Balcarres, is situated in the township of Upholland in the parish of Wigan, Lancashire. Its present depth from the surface is only 40 yards, for the mine having been recently commenced no extensive workings have, as yet, been effected. The vein is 6 feet in thickness, and is divided in the middle into two parts by 6 inches of clay. It has an inclination of one in five towards the north, and appears to be tolerably regular.

The subjacent and overlying strata consist of "argillaceous rock, blue metal, and black shale." Mr. Peace states, that this mine is worked by "narrow ends and walls, and in drifts about 5 yards wide."

The current price of the coal is 6*s.* 8*d.* per ton at the pit. The principal market is Liverpool, from which port the mine is distant about 12 miles by railway. The specimen of this coal which came into our hands, was tolerably hard, with a cubical fracture and full

black colour; but little iron pyrites was observed in it, although a considerable quantity of the white shaly matter mentioned in former parts of this Report was perceived in the lines of stratification. During the experiments, it was observed to burn steadily and blow off the steam rapidly. After a certain time, however, the bars get partially choked by a brittle whitish clinker, which is found in rather large quantities at the close of the experiments. It has also, in common with other coals from the same neighbourhood, the disadvantage of giving off much smoke during its combustion.

—	June 20, 1st day.	June 21, 2nd day.	June 22, 3rd day.
Fire lighted	9 h. 40 m.	9 h. 30 m.	8 h. 10 m.
Steam up	10 h. 0 m.	10 h. 5 m.	8 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	200°	206°	204°
Temperature of water in tanks	65°	70°	74°
Barometer	30·15 in.	30·15 in.	30·03 in.
Extremes of external thermometer	54°—68°	59°—74°	58°—75°
Extremes of internal thermometer	65°—71°	68°—76°	71°—77°
Dewpoint	55°	57°	50°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	601 lbs.	418 lbs.	582 lbs.
Weight of ashes left	7 lbs.	11 lbs.	16 lbs.
Per centage of combustible matter in ashes	27·9	24·5	39·5
Weight of cinder left	11 lbs.	9 lbs.	9 lbs.
Per centage of combustible matter in cinder	89·4	65·4	26·3
Weight of clinder in cinder	8 lbs.	4 lbs.	4 lbs.
Average weight of soot in flues	·8 lbs.	·8 lbs.	·8 lbs.
Per centage of combustible matter in soot	78·7	..	..
Weight of water evaporated	3740 lbs.	2840 lbs.	3780 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·20 lbs.	7·72 lbs.	7·42 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·02 lbs.	10·45 lbs.	14·55 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·260	..	..
Mean weight of cubic foot of coal	51·16 lbs.	..	..
Economic weight or space occupied by 1 ton	43·83 ft.	..	..
Cohesive power of coal	70·0	..	..

Note.—Final Temperature on fourth morning, 208°.

Balcarres Five-feet Mine.

I HEREBY certify that the five casks marked $\frac{H}{1}$, $\frac{H}{2}$, $\frac{H}{3}$, $\frac{H}{4}$, $\frac{H}{5}$, respectively, contain a fair sample of the Five-feet Mine Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM PEACE, *Agent*.

This mine is situated in the parish of Wigan, Lancashire, and is as yet only worked at a depth of about 40 yards from the surface. The vein is 5 feet 4 inches in thickness, and has been found to be regular so far as it has yet been proved. The subjacent and overlying strata are composed of "blue clay rock and black shale," which, together with the vein itself, have an inclination of 1 in 4 towards the north. This colliery is at present worked by walls, and is distant from Liverpool, which is the shipping port, about 13 miles. The coal is at present sold at 6*s*. 8*d*. per ton at the mine.

In appearance, it is similar to the last described, although the results of the experiments show its quality to be rather inferior to that from the Lindsay Mines.

It was found by experiment that this coal lights readily, and blows off the steam rapidly, but gives a hard clinker, which adheres so firmly to the bars as to interfere materially with the maintenance of a clear fire.

This coal gives off much smoke during combustion, and leaves a considerable amount of reddish ash.

—	June 23, 1st day.	June 24, 2nd day.	June 26, 3rd day.
Fire lighted	8 h. 0 m.	8 h. 15 m.	8 h. 45 m.
Steam up	8 h. 15 m.	8 h. 35 m.	9 h. 15 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	210°	183°
Temperature of water in tanks	70°	68°	68°
Barometer	29·7 in.	29·7 in.	30·13 in.
Extremes of external theremometer	57°—74°	53°—67°	56°—69°
Extremes of internal thermometer	70°—76°	67°—74°	66°—72°
Dewpoint	62°	51°	59°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	659 lbs.	552 lbs.	633 lbs.

	June 23, 1st day.	June 24, 2nd day.	June 26, 3rd day.
Weight of ashes left	10 lbs.	9 lbs.	11 lbs.
Per centage of combustible matter in ashes	45·4	27·0	12·2
Weight of cinder left	13 lbs.	13 lbs.	14 lbs.
Per centage of combustible matter in cinder	48·1	52·6	75·4
Weight of clinker in cinder	7 lbs.	5 lbs.	6 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	72·4	..	..
Weight of water evaporated	4500 lbs.	3350 lbs.	3870 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·79 lbs.	6·60 lbs.	7·23 lbs.
Weight of coals per hour for 1 square foot of grate surface	16·47 lbs.	13·30 lbs.	15·82 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·268	..	..
Mean weight of cubic foot of coal	49·0 lbs.	..	..
Economic weight or space occupied by 1 ton	45·71 ft.	..	..
Cohesive power of coal	44·5	..	..

Note.—Final temperature on fourth morning, 208°.

Balcarres Haigh Yard Mine.

I HEREBY certify that the five casks marked $\frac{B}{1}$, $\frac{B}{2}$, $\frac{B}{3}$, $\frac{B}{4}$, $\frac{B}{5}$, respectively, contain a fair sample of the Haigh Yard Mine Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM PEACE, *Agent.*

This colliery is situated in the township of Haigh, parish of Wigan, Lancashire, and is worked at a depth of 98 yards from the surface, where the vein is 34½ inches in thickness, and very regular. The overlying and subjacent strata are composed of "argillaceous rock, indurated clay, and bass." The vein has an inclination of 1 in 20 towards the south-east, and yields a free burning coal. The present method of working is by narrow drifts about 12 yards apart, and bringing back the intervening space as breast work. The chief markets for the coal are Preston and Liverpool, from which latter place the mine is distant about 20 miles. The present current price is, at the mine, 6*s.* per ton; and if delivered at Liverpool, 9*s.* per ton is charged; but the cost of carriage will be considerably reduced on the opening of the Liverpool and Bury Canal. This coal resembles in appearance the two last specimens described, and was found during our experiments to burn in a nearly similar way, with the exception of its being consumed rather less rapidly and more steadily than the other specimens. The clinker was found to be small in quantity, but extremely fusible, and by melting on the bars, obstructed the draught.

	June 27, 1st day.	June 28, 2nd day.	June 29, 3rd day.
Fire lighted	8 h. 20 m.	8 h. 10 m.	9 h. 0 m.
Steam up	8 h. 40 m.	8 h. 30 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	206°	206°
Temperature of water in tanks	66°	68°	67°
Barometer	29·9 in.	29·97 in.	29·8 in.
Extremes of external thermometer	58°—69°	51°—69°	48°—70°
Extremes of internal thermometer	69°—72°	66°—73°	68°—74°
Dewpoint	59°	53°	54°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	531 lbs.	431 lbs.	476 lbs.
Weight of ashes left	13 lbs.	15 lbs.	23 lbs.
Per centage of combustible matter in ashes	34·1	46·7	28·1
Weight of cinder left	10 lbs.	21 lbs.	21 lbs.
Per centage of combustible matter in cinder	51·7	65·1	81·1
Weight of clinker in cinder	7 lbs.	5 lbs.	5 lbs.
Average weight of soot in flues	1·16 lbs.	1·16 lbs.	1·16 lbs.
Per centage of combustible matter in soot	66·3	..	..
Weight of water evaporated	3160 lbs.	3060 lbs.	3540 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	6·79 lbs.	8·65 lbs.	8·26 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·27 lbs.	10·14 lbs.	11·90 lbs.
Duration of experiment	8 hrs.	8·5 hrs.	8 hrs.
Specific gravity of coal	1·284	..	..
Mean weight of cubic foot of coal	50·83 lbs.	..	..
Economic weight or space occupied by 1 ton	44·13 ft.	..	..
Cohesive power of coal	80·0	..	..

Note.—Final temperature on fourth morning, 185°.

Coals from Conception Bay, Chili.

The specimen experimented on at this place was sent for that purpose from Her Majesty's Dockyard, Woolwich, September 8, 1848, and weighed 410 lbs.

This coal closely resembles the splints from the neighbourhood of Newcastle, being hard and bright, with iron pyrites, and vegetable impressions which appear to be more recent than those found in the English coal-fields, as in many instances they resemble imperfectly charred wood. The quantity sent us not being sufficient to make a complete set of experiments, we were obliged to limit the time of trial under the boiler to five hours, during which time 403 lbs. of coal were consumed, and 2125 lbs. of water evaporated from 60° Fahrenheit. It was also found to light readily, burn freely, and give off much smoke, leaving rather large quantities of white ash and clinker, which require considerable attention on the part of the stoker in order to prevent the clogging of the bars. With care, however, a good fire, with a long flame, can be obtained, as the coal burns more like wood than any of the other varieties yet examined.

	September 16.
Fire lighted	9 h. 0 m.
Steam up	9 h. 30 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	208°
Temperature of water in tanks	60°
Barometer	30·52 in.
Extremes of external thermometer	..
Extremes of internal thermometer	60°—66°
Dewpoint	53°
Area of damper open	84 in.
Weight of coals consumed	403 lbs.
Weight of ashes left	26 lbs.
Per centage of combustible matter in ashes	62·5
Weight of cinder left	inc. in ash.
Per centage of combustible matter in cinder	..
Weight of clinker in cinder	8 lbs.
Average weight of soot in flues	..
Per centage of combustible matter in soot	..
Weight of water evaporated	2125 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	5·72 lbs.
Weight of coals per hour for 1 square foot of grate surface	16·12 lbs.
Duration of experiment	5 hrs.
Specific gravity of coal	1·291
Mean weight of cubic foot of coal	..
Economic weight or space occupied by 1 ton	..
Cohesive power of coal	..

Note.—Final temperature, 188°.

Balcarres Arley Mine.

I hereby certify that the six casks marked $\frac{M}{1}$, $\frac{M}{2}$, $\frac{M}{3}$, $\frac{M}{4}$, $\frac{M}{5}$, $\frac{M}{6}$, respectively contain a fair sample of the Arley Mine coals, which were mined specially for the service of the "Admiralty Coals Investigation."—William Peace, *Agent*.

The Arley Colliery is situated in the township of Haigh, parish of Wigan, Lancashire, and is worked at a depth of 212 yards from the surface, where the vein is 5 feet 6 inches in thickness, and very regular, with an inclination of 1 in 7 towards the south-east. This coal is described as "semi-bituminous," and is worked by walls 10 yards wide.

This mine is situated at a distance of 13 miles from Preston, which is the principal market for the coal. The current price is 6*s*. per ton at the pit.

In appearance, this coal differs but little from the other specimens sent for trial by the Earl of Balcarres, except that the lines of stratification are less strongly marked, it is also more free from white shale than the other varieties.

During the course of our experiments this coal was found to light easily and burn freely, but with the evolution of much smoke during the whole time of its combustion.

The amount of ash left was rather considerable, but the quantity of clinker formed was so small that, at the expiration of eight hours from the time of lighting the fire, the draught ways between the bars remained nearly as clear as before the commencement of the operation. The small quantity of clinker formed was very fusible, and adhered to the bars.

—	October 19, 1st day.	October 20, 2nd day.	October 21, 3rd day.
Fire lighted	8 h. 30 m.	8 h. 40 m.	8 h. 45 m.
Steam up	8 h. 50 m.	9 h. 0 m.	9 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	200°	210°	204°
Temperature of water in tanks	48°	50°	50°
Barometer	29·7 in.	29·83 in.	29·9 in.
Extremes of external thermometer	44°—51°	44°—51°	39°—56°
Extremes of internal thermometer	51°—63°	57°—64°	57°—66°
Dewpoint	50°	50°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	533 lbs.	419 lbs.	472 lbs.
Weight of ashes left	13 lbs.	12 lbs.	8 lbs.
Per centage of combustible matter in ashes	32·8	39·5	25·1
Weight of cinder left	9 lbs.	17 lbs.	15 lbs.
Per centage of combustible matter in cinder	60·7	55·8	75·1
Weight of clinker in cinder	2 lbs.	2 lbs.	3 lbs.
Average weight of soot in flues	1·16 lbs.	1·16 lbs.	1·16 lbs.
Per centage of combustible matter in soot	72·7	..	..
Weight of water evaporated	4138 lbs.	3210 lbs.	3550 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·17 lbs.	8·78 lbs.	8·54 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·32 lbs.	10·22 lbs.	11·8 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·269	..	..
Mean weight of cubic foot of coal	50·50 lbs.	..	..
Economic weight or space occupied by 1 ton	44·35 ft.	..	..
Cohesive power of coal	76·0	..	..

Note.—Final temperature on fourth morning, 190°.

Carr's Hartley Coal.

I HEREBY certify that the boxes marked No. 1, Carr's Hartley, contain a fair sample of the Carr's Hartley steam-coal, which was mined specially for the service of the "Admiralty Coals Investigation."—CHARLES CARR, *a Proprietor and Agent.*

The mine from which this coal was extracted is situated at Seighill, a township in the parish of Earsdon, eight miles north-east from Newcastle, and six miles from the River Tyne, where the coals are shipped by means of spouts. The colliery is worked at a depth of 100 fathoms from the surface, where a regular vein of 5 feet in thickness is found. This seam has an inclination of 1 in 36 towards the south-east.

The overlying and subjacent strata are composed of various beds of shale and sandstone, intermixed with the seams of coal.

This colliery is worked by the "board" and "pillar" system, and the produce is described "as one of the best steam-coals in the county of Northumberland, burning very freely and requiring little stoking." It is also represented as containing little sulphur, and leaving but a small quantity of whitish ash.

In this mine 600 men and boys are constantly employed, and 670 tons of coals are, on an average, daily brought to the surface and transported to the River Tyne by rail, from whence it is shipped for all the European ports, as well as for the East Indies and Red Sea. The current price on the Tyne is *7s.* 6*d.* per ton. The specimen sent for trial was hard and splinty, with the lines of deposition distinctly marked and free from iron pyrites and white shale, but contained many vegetable impressions, and a considerable amount of mineralized charcoal, which form thin beds in the lines of cleavage.

It was found, during our experiments, to light easily, burn freely, and blow off the steam rapidly, with the evolution of much smoke, and the deposit of a considerable amount of soot in the flues. Large quantities of white ash were also produced by its combustion, which makes considerable attention necessary on the part of the stoker to prevent the clogging of the grate, and the consequent stoppage of the draught. The amount of clinker found was not large, and rather resembled burnt shale than slag, as it did not fuse or adhere to the bars.

—	October 23, 1st day.	October 24, 2nd day.	October 25, 3rd day.
Fire lighted	8 h. 40 m.	8 h. 20 m.	8 h. 35 m.
Steam up	9 h. 15 m.	8 h. 50 m.	8 h. 55 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	190°	205°	205°
Temperature of water in tanks	52°	54°	54°
Barometer	29·67 in.	29·68 in.	29·70 in.
Extremes of external thermometer	50°—52°	50°—58°	40°—55°
Extremes of internal thermometer	59°—67°	59°—68°	61°—69°
Dewpoint	53°	52°	51°

	October 23, 1st day.	October 24, 2nd day.	October 25, 3rd day.
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	501 lbs.	343 lbs.	395 lbs.
Weight of ashes left	10 lbs.	10 lbs.	10 lbs.
Per centage of combustible matter in ashes	36·7	45·4	68·7
Weight of cinder left	14 lbs.	16 lbs.	11 lbs.
Per centage of combustible matter in cinder	85·9	83·1	81·8
Weight of clinker in cinder	0·3 lbs.	..	0·1 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	85·0	..	..
Weight of water evaporated	3385 lbs.	2210 lbs.	2670 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·006 lbs.	7·41 lbs.	7·74 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·52 lbs.	8·57 lbs.	9·87 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·254	..	..
Mean weight of cubic foot of coal	47·83 lbs.	..	..
Economic weight or space occupied by 1 ton	46·86 ft.	..	..
Cohesive power of coal	77·5	..	..

Note.—Final temperature on fourth morning, 202°.

North Percy, Hartley.

I HEREBY certify that the eight casks marked $\frac{\text{N. P. H.}}{\text{H C}}$ contain a fair sample of the North Percy Hartley coals, which were mined specially for the service of the "Admiralty Coals Investigation."—M. PLUMMER, *Proprietor.*

This coal is extracted from the main seam in the parish of Earsdon, five miles north from Tynemouth, and seven north-east of Newcastle-on-Tyne. The colliery is 220 feet in depth, and worked by the usual "board and pillar" system, as practised in the counties of Northumberland and Durham. The seam at present worked is 5 feet in thickness, and, as far as yet explored, perfectly regular. It has an inclination of 1 in 36 towards the west, and is covered by the usual sandstone and shale of the Newcastle district. This coal is shipped at Tynemouth for the different home and foreign markets, and is described "As tough in its texture and loose burning without any tendency to choke the draught." The current price is 8*s.* per ton.

The specimen which came into our hands was a splint of a resinous lustre with a full black colour, and appeared to contain a considerable amount of sulphur, as much iron pyrites and white shaly matter was observed in the fissures parallel to the lines of stratification. The experiments showed that this coal lights easily and burns freely, leaving a rather considerable amount of ash, and but little clinker, which is infusible, and therefore does not adhere to the bars or interfere with the draughts. Much smoke was given off during the whole time of the experiments, and whenever the fire doors were opened, a distinct odour of sulphur was perceived. A good clear fire can, however, be maintained with this coal, and the generation of steam goes on rapidly.

	October 26, 1st day.	October 31, 2nd day.	November 1, 3rd day.
Fire lighted	8 h. 40 m.	8 h. 40 m.	8 h. 35 m.
Steam up	9 h. 5 m.	9 h. 10 m.	9 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	202°	202°	206°
Temperature of water in tanks	53°	50°	50°
Barometer	29·98 in.	29·70 in.	29·71 in.
Extremes of external thermometer	44°—58°	42°—50°	41°—50°
Extremes of internal thermometer	59°—78°	56°—63°	57°—62°
Dewpoint	..	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	585 lbs.	474 lbs.	504 lbs.
Weight of ashes left	12 lbs.	12 lbs.	14 lbs.
Per centage of combustible matter in ashes	14·4	35·4	15·7
Weight of cinder left	14·75 lbs.	7 lbs.	10·75 lbs.
Per centage of combustible matter in cinder	80·1	69·3	55·2
Weight of clinker in cinder	3·25 lbs.	1 lb.	1·25 lbs.
Average weight of soot in flues	·5 lbs.	·5 lbs.	·5 lbs.
Per centage of combustible matter in soot	72·5	..	..
Weight of water evaporated	3750 lbs.	3140 lbs.	3275 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·43 lbs.	7·74 lbs.	7·54 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·62 lbs.	11·85 lbs.	12·60 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·255	..	..
Mean weight of cubic foot of coal	49·16 lbs.	..	..
Economic weight or space occupied by 1 ton	45·62 ft.	..	..
Cohesive power of coal	60·0	..	..

Note.—Final temperature on fourth morning, 206°.

Hastings Hartley Coal.

I HEREBY certify that the eight casks marked "From Hastings Hartley Colliery," contain a fair sample of the Hastings Hartley Main coal, which was mined specially for the service of the "Admiralty Coals Investigation."—JOSEPH LAMB, *Proprietor.*

This colliery, which is worked in what is called the Low Main Coal Seam, is situated seven miles from North Shields and 10 miles north-east of Newcastle.

The coal is worked at a depth of 103 fathoms from the surface, where the seam is generally about 5 feet 4 inches in thickness, although it is sometimes contracted to about 3 feet. The mean dip is 2 inches in the yard towards the south-east. The seam is covered by sandstone and shale, which has the same inclination as the coal. The mine is worked by the "board" and "wall" system, and is about seven miles distant from Howdon on the Tyne, where it is shipped for London, France, Denmark, the Baltic, Holland, and the Mediterranean, as also to the Black Sea.

The present current price, 7*s.* 6*d.* per ton on board at Howdon.

This coal in appearance very much resembles the foregoing, except that the lines of stratification are not so strongly marked, and that it contains less iron pyrites and white shale.

With careful stoking this coal yields a good fire, and little smoke is evolved during its combustion. The clinker is small in quantity, and does not adhere to the bars.

	November 2, 1st day.	November 3, 2nd day.	November 4, 3rd day.
Fire lighted	9 h. 15 m.	9 h. 0 m.	8 h. 45 m.
Steam up	9 h. 30 m.	9 h. 30 m.	9 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	192°	210°
Temperature of water in tanks	51°	52°	44°
Barometer	29·70 in.	29·65 in.	29·80 in.
Extremes of external thermometer	41°—52°	39°—54°	29°—50°
Extremes of internal thermometer	58°—63°	59°—64°	53°—64°
Dewpoint	..	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	579 lbs.	367 lbs.	480 lbs.
Weight of ashes left	9 lbs.	15 lbs.	9 lbs.
Per centage of combustible matter in ashes	22·0	34·0	10·5
Weight of cinder left	7·4 lbs.	14 lbs.	10 lbs.
Per centage of combustible matter in cinder	69·7	93·50	73·70
Weight of clinker in cinder	·6 lbs.	None.	·5 lbs.
Average weight of soot in flues	·33 lbs.	·33 lbs.	·33 lbs.
Per centage of combustible matter in soot	82·6	..	..
Weight of water evaporated	4160 lbs.	2330 lbs.	3220 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·18 lbs.	7·65 lbs.	7·49 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·47 lbs.	9·17 lbs.	12·0 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·251	..	..
Mean weight of cubic foot of coal	48·5 lbs.	..	..
Economic weight or space occupied by 1 ton.	46·18 ft.	..	..
Cohesive power of coal	75·5	..	..

Note.—Final temperature on fourth morning, 184°.

Hedley's Hartley Coal.

I HEREBY certify that the five casks marked "On Her Majesty's Service," addressed to J. Arthur Phillips, Esq., and numbered respectively 1 to 5, contain a fair sample of Hedley's Hartley Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—GEORGE HEDLEY, *Proprietor.*

This coal is extracted at a depth of 60 fathoms from the so-called $\frac{5}{4}$ seam, situated at Holmside, in the parish of Lanchester, in the county of Durham. The vein is regular, and has a total thickness of 4 feet 4 inches, of which 2 feet 8 inches are used as household coal, and the remaining 1 foot 8 inches for steam purposes.

The subjacent and overlying strata are composed of silicious and argillaceous rock, which, together with the seam, has a rise of half an inch in the yard. In working this seam the lower part, consisting of steam coal, is first cut away, after which the upper portion or household coal is allowed to fall. The coals are shipped at Shields, from which port the mine is distant about 16 miles by railway. The principal markets are London, the Mediterranean, and the Brazils.

The specimen sent to the Investigation was a hard dull coal with a cubical fracture, containing apparently but little iron pyrites, but a considerable amount of the white shaly matter, of which an analysis has been given.

Under the boiler it was found to light readily, but the generation of steam goes on slowly, and a quick draught is required to produce even a tolerable fire. A few hours after the commencement of the experiments the bars were found to have become choked by the large quantities of cinder and shaly ash, which results from the combustion of the coal,

and the fire required frequent stoking and constant attention in order to keep up the steam. At the close of the experiments large quantities of cinder and ash remained on the grate.

—	November 20, 1st day.	November 21, 2nd day.	December 2, 3rd day.
Fire lighted	12 h. 50 m.	9 h. 35 m.	9 h. 30 m.
Steam up	1 h. 35 m.	9 h. 55 m.	10 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	168°	202°	173°
Temperature of water in tanks	50°	50°	48°
Barometer	29·75 in.	29·78 in.	29·80 in.
Extremes of external thermometer	44°—54°	40°—54°	32°—53°
Extremes of internal thermometer	54°—59°	55°—60°	47°—56°
Dewpoint	48°	46°	47°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	418 lbs.	315 lbs.	354 lbs.
Weight of ashes left	20 lbs.	15 lbs.	16 lbs.
Per centage of combustible matter in ashes	34·0	22·7	13·4
Weight of cinder left	23 lbs.	34 lbs.	35 lbs.
Per centage of combustible matter in cinder	74·6	68·5	81·5
Weight of clinker in cinder	3 lbs.	2 lbs.	2 lbs.
Average weight of soot in flues	·33 lbs.	·33 lbs.	·33 lbs.
Per centage of combustible matter in soot	84·4	..	..
Weight of water evaporated	2990 lbs.	2240 lbs.	2290 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·77 lbs.	8·22 lbs.	7·49 lbs.
Weight of coals per hour for 1 square foot of grate surface	10·45 lbs.	7·0 lbs.	8·85 lbs.
Duration of experiment	8 hrs.	9 hrs.	8 hrs.
Specific gravity of coal	1·311	..	..
Mean weight of cubic foot of coal	52·0 lbs.	..	..
Economic weight or space occupied by 1 ton	43·07 ft.	..	..
Cohesive power of coal	85·5	..	..

Note.—Final temperature on third morning, 203°.
Final temperature on fourth morning, 172°.

Experimental Fuels.

It having been repeatedly stated by eminent engineers that the value of fuel for steam purposes depends upon the quantity of fixed carbon which it contains, it was thought that the addition of a portion of powdered anthracite or coke-dust to the ingredients employed in the manufacture of the various patent fuels might materially improve their quality; and in order to test the accuracy of this opinion, as well as to ascertain the best proportions to be employed, the following experiments were undertaken at Swansea, the proprietors of Warlich's patent fuel-works having kindly allowed the use of their apparatus for the purpose. At this manufactory the fuel is prepared by intimately blending fine coal with gas-tar, and then pressing the mixture into the form of bricks by means of powerful machinery worked by steam-power. These blocks, when they first come from the presses, are necessarily soft and unfit for stowage, besides containing large quantities of volatile matters, which would unfavourably affect their quality as fuel.

In order to eliminate these, the blocks are placed on an iron trellis and baked for several hours in ovens constructed for that purpose, and from whence, after cooling, they are removed in a fit state to be employed for the generation of steam.

The ingredients are usually employed in this manufactory in the following proportions: one ton of coal-dust, containing on an average 16 gallons of water, is intimately mixed with 16 gallons of coal-tar, and the resulting compound pressed into blocks.

In our experiments we used the following proportions, by weight, viz., in the fuel marked $\frac{A}{20}$, 80 parts of dry coal, 20 of powdered anthracite, and 7·2 of coal-tar were employed, and to these were added 7 parts of water, as without it it was found impossible to obtain well-shaped blocks.

That marked $\frac{B}{40}$ was made of 60 parts of dry coal, 40 parts of powdered anthracite, 7·8 parts of coal-tar, and 7 parts of water.

That marked $\frac{C}{60}$ was manufactured from 40 parts of common coal, 60 parts of anthracite, 8·3 parts of coal-tar, and 7 parts of water.

That marked $\frac{D}{20}$ was made from 80 parts of coal, 20 parts of coke-dust, 8·3 parts of coal-tar, and 7 parts of water.

Whilst the fuel marked $\frac{E}{40}$ was manufactured from a mixture of 60 parts of coal, 40 parts of anthracite, 8·3 parts of coal-tar, and 7 parts of water.

The results obtained during the practical trials of these fuels will be found in the following tables, from which it will be seen that each experiment occupied 24 hours.

Experimental Fuel, $\frac{A}{20}$.

Under the boiler this fuel was found to burn tolerably well when first thrown on the grate, but the fire soon gets dull, even with a quick draught, from the grate becoming choked by large quantities of ash, which speedily obstruct the draught. Some clinker was also formed during its combustion, but the amount of this was small compared with that of ash. This fuel was also observed to split into small fragments, and finally crumble into dust when the cement of coal-tar had burned away. The fire required constant attention and much stoking in order to keep up the steam.

—	December 4, 5.
Fire lighted	10 h. 10 m.
Steam up	11 h. 40 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	168°
Temperature of water in tanks	48°
Barometer	29·6 in.
Extremes of external thermometer	41°—52°
Extremes of internal thermometer	52°—60°
Dewpoint	..
Area of damper open	168 in.
Weight of fuel consumed	937 lbs.
Weight of ashes left	243 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	None
Per centage of combustible matter in cinder	..
Weight of clinker	21 lbs.
Average weight of soot in flues	None
Per centage of combustible matter in soot	..
Weight of water evaporated	5960 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	7·55 lbs.
Weight of fuel per hour for 1 square foot of grate surface	7·80 lbs.
Duration of experiment	24 hrs.
Specific gravity of fuel	1·173
Mean weight of cubic foot of fuel	65·6 lbs.
Economic weight or space occupied by 1 ton	..
Cohesive power of fuel	..

Note.—Final temperature, 182°.

Experimental Fuel, $\frac{B}{40}$.

This fuel burned precisely like the preceding.

—	December 6, 7.
Fire lighted	10 h. 10 m.
Steam up	11 h. 50 m.
Weight of wood used	10 lbs.
Initial temperaturre of water in boiler	182°
Temperature of water in tanks	48°
Barometer	29·65 in.
Extremes of external thermomer	45°—54°
Extremes of internal thermometer	54°—62°
Dewpoint	..
Area of damper open	168 in.
Weight of fuel consumed	963 lbs.
Weight of ashes left	291 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	None
Per centage of combustible matter in cinder	..
Weight of clinker	23 lbs.
Average weight of soot in flues	None
Per centage of combustible matter in soot	..
Weight of water evaporated	6170 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	7·62 lbs.
Weight of fuel per hour for 1 square foot of grate surface	8·02 lbs.
Duration of experiment	24 hrs.
Specific gravity of fuel	1·133
Mean weight of cubic foot of fuel	68·1 lbs.
Economic weight or space occupied by 1 ton	..
Cohesive power of fuel	..

Note.—Final temperature, 204°.

Experimental Fuel, $\frac{C}{60}$.

Although this fuel burns similarly to the preceding, it appears to yield a clearer fire when first lighted; but as in the other cases, the grate soon grows choked with ash, and the fire becomes dull. It was also observed that this fuel burnt best when thrown on the fire in large lumps. No smoke was given off either by this or the preceding samples.

——	Dec. 8, 9.
Fire lighted	10 h. 45 m.
Steam up	12 h. 0 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	204°
Temperature of water in tanks	52°
Barometer	29·99 in.
Extremes of external thermometer	48°—54°
Extremes of internal thermometer	57°—62°
Dewpoint	..
Area of damper open	168 in.
Weight of fuel consumed	766 lbs.
Weight of ashes left	173 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	35 lbs.
Per centage of combustible matter in cinder	..
Weight of clinker in cinder	14 lbs.
Average weight of soot in flues	..
Per centage of combustible matter in soot	..
Weight of water evaporated	5470 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	7·87 lbs.
Weight of fuel per hour for 1 square foot of grate surface	6·38 lbs.
Duration of experiment	24 hrs.
Specific gravity of fuel	1·137
Mean weight of cubic foot of fuel	69·9 lbs.
Economic weight or space occupied by 1 ton	..
Cohesive power of fuel	..

Note.—Final temperature, 148°.

Experimental Fuel, $\frac{D}{20}$.

This fuel burns very badly, like $\frac{A}{20}$, yielding much clinker and ash, and requires frequent stoking in order to maintain combustion.

——	Dec. 11, 12.
Fire lighted	10 h. 30 m.
Steam up	1 h. 0 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	148°
Temperature of water in tanks	52°
Barometer	30·32 in.
Extremes of external thermometer	50°—53°
Extremes of internal thermometer	58°—64°
Dewpoint	..
Area of damper open	168 in.
Weight of fuel consumed	860 lbs.
Weight of ashes left	284 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	None.
Per centage of combustible matter in cinder	..
Weight of clinker	29 lbs.
Average weight of soot in flues	None.
Per centage of combustible matter in soot	..
Weight of water evaporated	4810 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	6·76 lbs.
Weight of fuel per hour for 1 square foot of grate surface	7·16 lbs.
Duration of experiment	24 hrs.
Specific gravity of fuel	1·204
Mean weight of cubic foot of fuel	62·1 lbs.
Economic weight or space occupied by 1 ton	..
Cohesive power of fuel	..

Note.—Final temperature, 188°.

Experimental Fuel, $\frac{E}{40}$.

This fuel burns tolerably well, and but for the large quantities of ash and clinker, especially the latter, a good fire might be maintained, and the steam rapidly generated. In the early part of the experiments a clear fire was produced, the fuel appearing to burn as well as ordinary Welsh coals; but as the trial proceeded the bars became choked, and the clearness of the fire destroyed. A little grey smoke was sometimes observed at the chimney top.

—	December 13, 14.
Fire lighted	10 h. 45 m.
Steam up	11 h. 15 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	188°
Temperature of water in tanks	52°
Barometer	30·25 in.
Extremes of external thermometer	49°—54
Extremes of internal thermometer	60°—68°
Dewpoint	..
Area of damper open	168 in.
Weight of fuel consumed	1053 lbs.
Weight of ashes left	176 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	None
Per centage of combustible matter in cinder	..
Weight of clinker	36 lbs.
Average weight of soot in flues	None
Per centage of combustible matter in soot	..
Weight of water evaporated	7880 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	8·83 lbs.
Weight of fuel per hour for 1 square foot of grate surface	8·77 lbs.
Duration of experiment	24 hrs.
Specific gravity of fuel	1·118
Mean weight of cublic foot of fuel	66·1 lbs.
Economic weight or space occupied by 1 ton	..
Cohesive power of fuel	..

Note.—Final temperature, 208°.

The foregoing experiments go to show that the addition of fixed carbon, either in the form of anthracite or coke, does not produce the advantageous results which might be anticipated; and this is probably owing to the fact of the cement and coal being first consumed, which causes the powdered anthracite and coke-dust either so to accumulate on the bars as to obstruct the draught, or to fall through the grate and escape combustion; and if it be again thrown on the fire, the air-way is choked and the action impeded. It will, however, be observed, by reference to the working tables, that the evaporative power is a little increased as the quantity of fixed carbon becomes larger; and this seems to arise from the circumstance that when the amount of coke or anthracite occurring in the mixture is small, the greater portion of it appears to escape combustion; whilst when a larger quantity is added, the fuel assumes in some degree the character of either the one or the other, as the case may be.

Cadoxton Fuel.

This sample was made by Warlich's Patent Fuel Company, and by them sent up for trial. In appearance it could not be distinguished from the ordinary fuels manufactured at their works, and differed from it only in being made from the Cadoxton coal, instead of that from the Graigola Mine, which is usually employed for that purpose.

Under the boiler it was found to burn badly, leaving a considerable amount of ash, which obstructed the draught, and required constant attention on the part of the stoker.

—	December 21, 22.
Fire lighted	9 h. 50 m.
Steam up	10 h. 45m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	172°
Temperature of water in tanks	36°
Barometer	30·30 in.
Extremes of external thermometer	28°—39°
Extremes of internal thermometer	43°—60°
Dewpoint	..
Area of damper open	112 in.

—	December 21, 22.
Weight of fuel consumed	1132 lbs.
Weight of ashes left	207 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	None
Per centage of combustible matter in cinder	..
Weight of clinker	74 lbs.
Average weight of soot in flues	None
Per centage of combustible matter in soot	..
Weight of water evaporated	7625 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	8·10 lbs.
Weight of fuel per hour for 1 square foot of grate surface	9·43 lbs.
Duration of experiment	24 hrs.
Specific gravity of fuel	1·273
Mean weight of cubic foot of fuel	72·3 lbs.
Economic weight or space occupied by 1 ton	..
Cohesive power of fuel	..

Note.—Final temperature, 200°.

ORIGINAL HARTLEY.

I HEREBY certify, that the casks marked No. 2 H contain a fair sample of the Original Hartley Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CHARLES CARR, *Proprietor.*

The pit from which these coals were extracted is situated about 10 miles north-east of Newcastle, and 2 miles from the port of Seaton Sluice, to which place a portion of the produce of the mine is conveyed in waggons drawn by locomotives, and where vessels of 400 tons burthen may load in safety. Another portion of the coal is conveyed by rail to the Tyne, which is at a distance of 8 miles, and there loaded by means of spouts.

This colliery is one of the oldest in the district, and is that from which the Northumberland coal derives its name. The daily produce of the mine is about 120 tons, the extraction of which occupies 110 men and boys; but, if necessary, four times this quantity might be raised. The present depth is 110 fathoms, where the seam is 4 feet 6 inches in thickness and very regular. The overlying and subjacent strata consist of various beds of sandstone and shale intermixed with seams of coal. The mine is worked by the "bond and pillar" system, and the coal described by the owner as "a hard and splinty open burning coal, free from sulphur, giving an intense heat and leaving a small portion of white ash."

The principal markets are London, France, and the Baltic. The present current price is 7*s.* 6*d.* per ton.

The specimen of this coal which came into our hands was hard and splinty, with the lines of stratification less distinctly developed than in many of the coals from the same district. Its general appearance was bright and resinous, without either iron pyrites or white shale; but impressions of reeds of a silky appearance were sometimes observed in the jointings.

During the experiments, it was found to light easily and blow off the steam rapidly; it also requires very little stoking, and leaves little ash, clinker, and cinder; but like all the other coals from the north of England, gives off much smoke during its combustion.

—	January 5, 1st day.	January 8, 2nd day.	January 9, 3rd day.
Fire lighted	9 h. 45 m.	9 h. 10 m.	9 h. 30 m.
Steam up	10 h. 50 m.	11 h. 0 m.	9 h. 55 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	120°	140°	204°
Temperature of water in tanks	34°	40°	43°
Barometer	29·98 in.	29·67 in.	29·68 in.
Extremes of external thermometer	30°—35°	38°—43°	39°—46°
Extremes of internal thermometer	42°—50°	43°—52°	46°—52°
Dewpoint	49°	50°	47°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	743 lbs.	562 lbs.	682 lbs.
Weight of ashes left	10 lbs.	17 lbs.	11 lbs.
Per centage of combustible matter in ashes	27·1	30·0	30·0
Weight of cinder left	15 lbs.	13 lbs.	10 lbs.
Per centage of combustible matter in cinder	76·0	93·0	96·0
Weight of clinker in cinder	5 lbs.	1 lb.	3 lbs.
Average weight of soot in flues	·66 lbs.	·66 lbs.	·66 lbs.
Per centage of combustible matter in soot	65·2	..	..
Weight of water evaporated	4260 lbs.	2810 lbs.	3855 lbs.

	January 5, 1st day.	January [illegible], 2nd d	January 9, 3rd day.
Weight of water evaporated from 212° by 1 lb. of coal	7·35 lbs.	6·50 lbs.	6·61 lbs.
Weight of coals per hour for 1 square foot of grate surface	18·57 lbs.	12·48 lbs.	16·04 lbs.
Duration of experiment	8 hrs.	9 hrs.	8·5 hrs.
Specific gravity of coal	1·250	..	..
Mean weight of cubic foot of coal	49·16 lbs.	..	..
Economic weight or space occupied by 1 ton	45·62 ft.	..	..
Cohesive power of coal	80·0	..	..

Note.—Final temperature on second morning, 200°.
Final temperature on fourth morning, 205°.

Derwentwater's Hartley.

I hereby certify that the six casks marked D. H. contain a fair sample of Derwentwater's Hartley Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—John R. Liddell.

The Derwentwater colliery is situated at a distance of 1½ mile from the port of Warkworth, where the coals are shipped. The pit is sunk on what is called the Princess Seam, which is supposed to be identical with the Low Main Seam on the Tyne, and the Hutton Seam on the Wear. Its width at this place varies from 4 to 5 feet, with a dip towards the south-west and north-east. The present depth of the workings is 75 fathoms.

The overlying and subjacent strata are composed of sandstone and shale, as is usual in the Newcastle district, and the coal is described by the agent as "hard and open burning, giving a strong heat, leaving a white ash and no clinker." The mine is worked by the "bond and pillar" system, and the coal chiefly used for the generation of steam, for which purpose large quantities are employed both in England and on the Continent.

The present current price is 6*s.* 6*d.* per ton. In appearance this coal resembles that last described, except that it is not quite so brilliant, and contains more distinct marks of reeds, and, apparently, a larger amount of iron pyrites. It also behaves very much in the same way under the boiler, but is more smoky, and contains a larger quantity of earthy matter, which causes more ash and clinker to be produced than in the case of the Original Hartley Coal.

	January 10, 1st day.	January 11, 2nd day.	January 12, 3rd day.
Fire lighted	9 h. 0 m.	9 h. 30 m.	9 h. 20 m.
Steam up	9 h. 35 m.	10 h. 15 m.	10 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	205°	201°	201°
Temperature of water in tanks	46°	40°	42°
Barometer	29·12 in.	29·67 in.	29·80 in.
Extremes of external thermometer	38°—48°	31°—41°	33°—50°
Extremes of internal thermometer	47°—54°	47°—52°	47°—55°
Dewpoint	37°·5	44°·6	49°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	589 lbs.	518 lbs.	631 lbs.
Weight of ashes left	13 lbs.	19 lbs.	16 lbs.
Per centage of combustible matter in ashes	45·4	56·7	62·5
Weight of cinder left	10 lbs.	16 lbs.	15 lbs.
Per centage of combustible matter in cinder	72·3	74·6	52·3
Weight of clinker in cinder	9 lbs.	5 lbs.	8 lbs.
Average weight of soot in flues	0·66 lbs.	·66 lbs.	·66 lbs.
Per centage of combustible matter in soot	54·9	..	..
Weight of water evaporated	3810 lbs.	3190 lbs.	4020 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·49 lbs.	7·21 lbs.	7·56 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·72 lbs.	12·95 lbs.	15·77 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·263	..	..
Mean weight of cubic foot of coal	50·41 lbs.	..	..
Economic weight or space occupied by 1 ton	44·44 ft.	..	..
Cohesive power of coal	63·5	..	..

Note.—Final temperature on fourth morning, 206°.

Gadly Ironwork Coals.

I HEREBY certify that the eight casks marked Gadly's, and numbered from $\frac{1 \text{ to } 4}{4 \text{ ft.}}$ and $\frac{1 \text{ to } 4}{9 \text{ ft.}}$, contain a fair sample of the Aberdare coals, which were mined specially for the service of the "Admiralty Coals Investigation."—THOMAS MAYNE, *for Gadly's Iron Company and Self.*

Gadly's Aberdare colliery is situated at a distance of 24 miles from Cardiff, which is the shipping port. Two veins are at present explored in this mine:—

The first, or so-called Four-feet Seam, is worked at a depth of 34 yards, and has a regular thickness of 5 feet, with an inclination of 3 inches in the yard towards the south. The overlying and subjacent strata are composed of strong shale. The mine is worked by "pit in the ordinary way," and the coal is described as free burning.

The second, or Nine-feet Seam, is mined at a depth of 90 yards from the surface; is regular, and has the thickness which its name indicates, with the same inclination and in the same direction as the Four-feet Seam.

This coal is employed by the proprietors at their ironworks, for the various operations of that manufacture.

The specimens received at Putney College were rather soft, and possessed in a remarkable degree a radiate semi-crystallized appearance, together with polished faces in the partings which seem to be produced by the sliding of one portion over the other, and which is often met with in the Welsh coal-fields. This was more particularly observed in the coal from the Four-feet Seam. The Nine-feet Seam, besides being more free from this appearance, contains bands of a dull friable substance, resembling mineralized charcoal, together with vegetable impressions and thin white shale.

Under the boiler little difference was observed in the burning of the coals from the two seams, as each gave a steady strong flame with no smoke, and left a large quantity of ash of a very incombustible nature, which, when again thrown on the grate, was found to choke the bars and interfere with the draught.

These coals were also found to require a strong draught in order to keep up a good fire. Little clinker was found on the bars at the close of the experiments, but that formed was of a red colour.

Gadly Four-feet Seam.

	January 16, 1st day.	January 17, 2nd day.
Fire lighted	9 h. 25 m.	10 h. 10 m.
Steam up	10 h. 20 m.	10 h. 35 m.
Weight of wood used	10 lbs.	10 lbs.
Initial temperature of water in boiler	198°	206°
Temperature of water in tanks	46°	50°
Barometer	29·70 in.	29·89 in.
Extremes of external thermometer	40°—53°	39°—55°
Extremes of internal thermometer	48°—58°	50°—63
Dewpoint	38°6	41°
Area of damper open	56 in.	168 in.
Weight of coals consumed	312 lbs.	477 lbs.
Weight of ashes left	45 lbs.	46 lbs.
Per centage of combustible matter in ashes	70·0	66·0
Weight of cinder left	29 lbs.	35 lbs.
Per centage of combustible matter in cinder	92·5	87·0
Weight of clinker in cinder	·06 lbs.	3 lbs.
Average weight of soot in flues	None.	..
Per centage of combustible matter in soot	..	..
Weight of water evaporated	2420 lbs.	3860 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·18 lbs.	9·4 lbs.
Weight of coals per hour for 1 square foot of grate surface	7·8 lbs.	11·92 lbs.
Duration of experiment	8 hrs.	8 hrs.
Specific gravity of coal	1·327	..
Mean weight of cubic foot of coal	51·66 lbs.	..
Economic weight or space occupied by 1 ton	43·41 ft.	..
Cohesive power of coal	68·5	..

Note.—Final temperature on third morning, 206°.

GADLY NINE-FEET SEAM.

	January 18, 1st day.	January 19, 2nd day.	January 20, 3rd day.
Fire lighted	9 h. 20 m.	8 h. 30 m.	9 h. 30 m.
Steam up	9 h. 50 m.	9 h. 0 m.	9 h. 50 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	208°	210°
Temperature of water in tanks	50°	51°	52°
Barometer	30·05 in.	30·00 in.	30·22 in.
Extremes of external thermometer	46°—52°	48°—54°	44°—53°
Extremes of internal thermometer	55°—62°	56°—63°	54°—64°
Dewpoint	37°	42°	43°
Area of damper open	112 in.	84 in.	168 in.
Weight of coals consumed	513 lbs.	452 lbs.	524 lbs.
Weight of ashes left	56 lbs.	68 lbs.	55 lbs.
Per centage of combustible matter in ashes	27·3	46·6	56·0
Weight of cinder left	20 lbs.	31 lbs.	20 lbs.
Per centage of combustible matter in cinder	70·0	81·0	82·0
Weight of clinker in cinder	1 lb.	1 lb.	2 lbs.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4290 lbs.	3520 lbs.	4605 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·72 lbs.	9·03 lbs.	9·95 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·82 lbs.	11·3 lbs.	13·1 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·333	..	..
Mean weight of cubic foot of coal	54·83 lbs.	..	..
Economic weight or space occupied by 1 ton	40·89 lbs.	..	..
Cohesive power of coal	76·0	..	..

Note.—Final temperature on fourth morning, 191°.

ABERDARE COMPANY'S MERTHYR.

I HEREBY certify that the six casks marked A. C., and numbered from one to six, contain a fair sample of the Merthyr Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM WILLIAMS, *Agent*.

This colliery is situated at Abernanty Groes y-chaf, Aberdare, Glamorganshire. The present depth of the mine is 45 yards, where the vein is regular, and 6 feet 6 inches in thickness with a dip of 3 inches in the yard towards the south. The overlying and subjacent strata are composed of strong shale, and the coal is described as "free burning."

This pit is 24 miles from Cardiff, where the coal is sold to Messrs. Wood and Company, who ship it under the name of Merthyr Coal to almost every part of the world.

The specimen examined by the officers of this investigation was brilliant. with a cubical fracture, but presented in many places the peculiar radiate appearance before observed in other varieties of coal from the same district. It was also harder than the generality of Welsh coal, and apparently very free from white shale and iron pyrites.

Under the boiler this coal yields good results, burning freely and giving a good fire, which is easily kept up without much attention on the part of the stoker being required.

At the close of the experiments very little ash or clinker was left, and but little smoke was evolved during its combustion. Its evaporative power was also found to be good, and the coal in every way fitted for steam purposes.

	Jan. 22, 1st day.	Jan. 23, 2nd day.	Jan. 24, 3rd day.
Fire lighted	9 h. 10 m.	8 h. 45 m.	10 h. 40 m.
Steam up	10 h. 15 m.	9 h. 45 m.	11 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	191°	198°	189°
Temperature of water in tanks	47°	48°	50°
Barometer	30·20 in.	30·40 in.	30·30 in.
Extremes of external thermometer	41°—47°	45°—52°	48°—52°
Extremes of internal thermometer	53°—60°	54°—62°	54°—60
Dewpoint	43°·5	45°	47°·5
Area of damper open	112 in.	84 in.	168 in.
Weight of coals consumed	458 lbs.	395 lbs.	506 lbs.
Weight of ashes left	18 lbs.	18 lbs.	16 lbs.
Per centage of combustible matter in ashes	42·4	59·8	52·9
Weight of cinder left	25 lbs.	17 lbs.	14 lbs.
Per centage of combustible matter in cinder	77·2	83·4	90·0
Weight of clinker in cinder	3 lbs.	2 lbs.	1 lb.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..

—	Jan. 22, 1st day.	Jan. 23, 2nd day.	Jan. 24 3rd day.
Weight of water evaporated	3695 lbs.	3415 lbs.	4150 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·49 lbs.	9·91 lbs.	9·80 lbs.
Weight of coals per hour for 1 square foot of grate surface	11·45 lbs.	9·87 lbs.	12·65 lbs.
Duration of experiment	8 hrs.	7·5 hrs.	7·5 hrs.
Specific gravity of coal	1·310	..	..
Mean weight of cubic foot of coal	49·33 lbs.	..	..
Economic weight or space occupied by 1 ton	45·43 ft.	..	..
Cohesive power of coal	74·5	..	..

Note.—Final temperature on fourth morning, 210°.

THOMAS'S MERTHYR.

I HEREBY certify that the five casks marked $\frac{I\ S}{1}$ and $\frac{I\ S}{2}$ contain a fair sample of the Merthyr Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM THOMAS, *Proprietor.*

This coal-mine is situated at Letty Shenkin, Aberdare, Glamorganshire, about 24 miles from Cardiff.

Its present depth is 120 yards. The seam has a thickness of 4 feet with an underlie of 4 feet in the yard towards the south. The colliery is worked by shaft and headings, and the coal is described as "free burning." This coal, like the preceding, is sold to Messrs. Wood and Company, of Cardiff, who export it from thence under the same name to almost all parts of the world for steam purposes.

The specimen sent for the use of the "Admiralty Coals Investigation" could not be distinguished from the Aberdare Company's Coal, except that it was not quite so firm, and perhaps a little less brilliant. Under the boiler the two coals behave in precisely the same manner, but the evaporative power of that now decribed is a little superior to that of the other.

—	Jan. 25, 1st day.	Jan. 26, 2nd day.	Jan. 27, 3rd day.
Fire lighted	9 h. 30 m.	9 h. 30 m.	9 h. 30 m.
Steam up	9 h. 45 m.	9 h. 55 m.	9 h. 45 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	210°	208°	210°
Temperature of water in tanks	50°	48°	44°
Barometer	30·17 in.	30·05 in.	30·04 in.
Extremes of external thermometer	46°—52°	31°—48°	36°—45°
Extremes of internal thermometer	58°—60°	52°—60°	49°—58°
Dewpoint	46°	45°	46°
Area of damper open	112 in.	84 in.	168 in.
Weight of coals consumed	501 lbs.	416 lbs.	505 lbs.
Weight of ashes left	32 lbs.	24 lbs.	16 lbs.
Per centage of combustible matter in ashes	56·0	45·1	58·8
Weight of cinder left	25 lbs.	15 lbs.	14 lbs.
Per centage of combustible matter in cinder	70·0	93·1	54·8
Weight of clinker in cinder	1 lb.	0·5 lbs.	1 lb.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4320 lbs.	3710 lbs.	4470 lbs
Weight of water evaporated from 212° by 1 lb. of coal	10·02 lbs.	10·37 lbs.	10·11 lbs
Weight of coals per hour for 1 square foot of grate surface	12·52 lbs.	10·15 lbs.	12·62 lbs.
Duration of experiment	8 hours.	8 hours.	8 hours.
Specific gravity of coal	1·302	..	..
Mean weight of cubic foot of coal	53·0 lbs.	..	..
Economic weight or space occupied by 1 ton	42·26 ft.	..	..
Cohesive power of coal	57·5	..	..

Note.—Final temperature on fourth morning, 192°.

BUDDLE'S WEST HARTLEY.

I HEREBY certify that the four casks marked Buddle's West Hartley, and addressed to J. Arthur Phillips, Esq., O.H.M.S.; Nos. 1, 2, 3, and 4, contain a fair sample of the Buddle's West Hartley coals, which were mined specially for the service of the "Admiralty Coals Investigation."—R. W. SWAN, *Agent.*

This colliery is on the Low Main seam, nine miles from Newcastle-on-Tyne. Its depth is 360 feet where the vein is 5 feet 2 inches in thickness, and very regular, with a dip of 1 in 30 towards the south. The overlying and subjacent strata consist of argillaceous and siliceous deposits. The mine has been worked for the last eight years, and during that

time specimens of the coal have been sent to nearly all parts of the world, to be employed for steam purposes, for which it is highly recommended.

The coal is worked by the "board and wall" system, gunpowder being sometimes employed to facilitate its extraction, and is described as "coarse and strong, free from clinker, and giving off but little smoke."

The present current price, loaded on the Tyne, is 8*s* per ton; and the agent adds, that it is admitted in all the English and French Government contracts.

The specimen examined by us was a hard resinous-looking splint, with numerous vegetable impressions in the joints of deposition, and a considerable amount of thin white shale in the cross-headings.

During the experiments it was found to burn freely, and blow off the steam rapidly, requiring but little trouble to maintain a good fire.

It was also observed to do better with a moderately quick than with a slow draught, and to evolve much smoke during the whole time of combustion.

	January 29, 1st day.	January 30, 2nd day.	January 31, 3rd day.
Fire lighted	9 h. 45m.	9 h. 30 m.	8 h. 50 m.
Steam up	10 h. 30m.	9 h. 50 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	192°	208°	206°
Temperature of water in tanks	40°	45°	44°
Barometer	29·9 in.	30·1 in.	30·2 in.
Extremes of external thermometer	30°—41°	31°—46°	32°—48°
Extremes of internal thermometer	49°—56°	47°—58°	46°—56°
Dewpoint	45°.5	46°	45°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	607 lbs.	401 lbs.	486 lbs.
Weight of ashes left	14 lbs.	14 lbs.	14 lbs.
Per centage of combustible matter in ashes	50·0	33·3	25·2
Weight of cinder left	9 lbs.	5 lbs.	7 lbs.
Per centage of combustible matter in cinder	85·7	91·3	77·2
Weight of clinker in cinder	2 lbs.	1 lb.	1 lb.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	85·3	..	..
Weight of water evaporated	3930 lbs.	2700 lbs.	3290 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·77 lbs.	7·83 lbs.	7·87 lbs.
Weight of coal per hour for 1 square foot of grate surface	15·17 lbs.	10·02 lbs.	12·15 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·236	..	..
Mean weight of cubic foot of coal	50·83 lbs.	..	..
Economic weight or space occupied by 1 ton	44·09 ft.	..	..
Cohesive power of coal	80·0	..	..

Note.—Final temperature on fourth morning, 206°.

Bate's West Hartley Coals.

I HEREBY certify that the five casks marked $\frac{\text{B. W. H.}}{\text{E. H. C.}}$ contain a fair sample of the Bate's West Hartley coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WALTER PLUMMER, *One of the Proprietors.*

This coal is the produce of the High Main seam at the East Holywell colliery, which is situated in the parish of Earsdon in the county of Northumberland, eight miles north-east of Newcastle-upon-Tyne. The mine is at present 42 fathoms in depth, and the seam varies from 5 feet to 5 feet 8 inches in thickness, with a dip of 1 in 16 towards the west. The coal is worked by the "board and pillar" system, as customary in that district. The shipping port, Newcastle, is at a distance of five miles from the mine, from whence about one-half its produce is exported to the various foreign markets, whilst the remainder is shipped for home consumption and is chiefly employed for steam purposes.

The proprietors describe this as "a good steam coal, which has been found by local experience to excel most others," and state its current price to be 8*s*. per ton. The specimen which came into our hands was a hard splinty coal, with a cubical fracture, and consisted of alternate deposits of hard resinous coal and mineralized charcoal, the quantity of which was less than in many other varieties of the Hartley coal. It also contained large quantities of thin white shale, both in the planes of deposition and in the cross-headings. Frequent patches of iron pyrites were also observed.

During the experiments this coal was found to burn like the other Hartleys, giving off much smoke and depositing large quantities of soot.

Little ash or clinker was, however, produced by its combustion, and a good fire may be maintained without much attention on the part of the stoker being required.

	February 1, 1st day.	February 2, 2nd day.	February 3, 3rd day.
Fire lighted	9 h. 10 m.	9 h. 30 m.	10 h. 35 m.
Steam up	9 h. 30 m.	10 h. 0 m.	11 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	200°	201°
Temperature of water in tanks	44°	47°	47°
Barometer	30·33 in.	30·20 in.	30·10 in.
Extremes of external thermometer	40°—52°	47°—50°	49°—54°
Extremes of internal thermometer	50°—59°	50°—61°	56°—59°
Dewpoint	40°	45°	43°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	516 lbs.	378 lbs.	493 lbs.
Weight of ashes left	14 lbs.	13 lbs.	10 lbs.
Per centage of combustible matter in ashes	31·1	62·1	29·2
Weight of cinder left	7 lbs.	12 lbs.	10 lbs.
Per centage of combustible matter in cinder	53·4	96·1	34·1
Weight of clinker in cinder	0·12 lbs.	none.	0·75 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	88·0	..	..
Weight of water evaporated	3810 lbs.	2420 lbs.	3535 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·54 lbs.	7·43 lbs.	8·16 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·90 lbs.	9·45 lbs.	12·32 lbs.
Duration of experiment	8 hrs.	8 hr	8 hrs.
Specific gravity of coal	1·253	..	..
Mean weight of cubic foot of coal	50·66 lbs.	..	..
Economic weight or space occupied by 1 ton	44·13 ft.	..	..
Cohesive power of coal	69·5	..	..

Note.—Final temperature on fourth morning, 185°.

Haswell Coals.

I HEREBY certify that the five casks marked HASWELL—SB—WE contain a fair sample of the Haswell Steam-boat Wallsend Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CHARLES TAYLOR, *Agent.*

This coal is raised at the Haswell colliery, six miles east of Durham, from the under part of the Hutton seam. The present depth of the mine is 936 feet. The total thickness of the Hutton seam is 5 feet 9 inches, with an underlie of 1 in 24, in an easterly direction. The overlying and subjacent strata consist of the ordinary shale and sandstones of the Newcastle coal formations, and the coal is described as well adapted for steam purposes, for which it is chiefly employed. The agent also states that the Haswell Steam-boat Wallsend is harder than the Tyne or Weir Steam-coal, and that from the circumstance of its being necessary to work the upper part of the Hutton seam before the lower portion or Steam-boat Wallsend can be extracted, the latter may be obtained in larger fragments than if it were worked alone.

These coals are chiefly exported to the various foreign markets, and may be shipped either from Sunderland, Hartlepool, or Seaham, from the two former of which ports the mine is situated at a distance of 9½ miles, whilst from the latter the distance is only six. The present current price is 8*s.* per ton.

The specimen which was experimented on presented the same general appearance as the Hartley coals, with spots of white shale, vegetable impressions, and iron pyrites, although the latter does not appear to exist to any very considerable extent. The shale is, however, very abundant, and seems to be intimately mixed with the coal throughout its structure. This sample was also less brilliant than the generality of the Hartley coals, and contains a a rather large quantity of mineralized charcoal.

Under the boiler this coal was found to light easily and burn freely, but did not blow off the steam very rapidly, as large quantities of white ash were produced, which speedily choked the fire and impeded the draught. Constant attention was, therefore, required on the part of the stoker, in order to keep up the steam. Much smoke was evolved during the experiments, though but little clinker was left on the bars.

	February 12, 1st day.	February 13, 2nd day.	February 14, 3rd day.
Fire lighted	9 h. 35 m.	9 h. 30 m.	9 h. 0 m.
Steam up	10 h. 40 m.	9 h. 50 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	145°	206°	200°
Temperature of water in tanks	44°	40°	44°
Barometer	30·20 in.	30·17 in.	30·50 in.
Extremes of external thermometer	27°—44°	26°—45°	43°—50°
Extremes of internal thermometer	39°—50°	40°—52°	48°—54°
Dewpoint	31°	38°	40°

	February 12, 1st day.	February 13, 2nd day.	February 14, 3rd day.
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	427 lbs.	342 lbs.	369 lbs.
Weight of ashes left	16 lbs.	21 lbs.	17 lbs.
Per centage of combustible matter in ashes	20·9	11·2	34·5
Weight of cinder left	19 lbs.	22 lbs.	19 lbs.
Per centage of combustible matter in cinder	69·7	56·5	78·7
Weight of clinker in cinder	3 lbs.	1 lb.	1 lb.
Average weight of soot in flues	·66 lbs.	·66 lbs.	·66 lbs.
Per centage of combustible matter in soot	80·9	..	..
Weight of water evaporated	2430 lbs.	2110 lbs.	2465 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·45 lbs.	7·06 lbs.	7·93 lbs.
Weight of coals per hour for 1 square foot of grate surface	10·67 lbs.	8·55 lbs.	9·22 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·272	..	..
Mean weight of cubic foot of coal	49·58 lbs.	..	..
Economic weight or space occupied by 1 ton	45 25 ft.	..	..
Cohesive power of coal	79·5	..	..

Note.—Final temperature on fourth morning, 208°.

Davison's West Hartley.

I HEREBY certify that the six casks marked respectively D.W.H. I. II. III. IV. V. and VI. contain a fair sample of the Davison's West Hartley Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JOHN MIDDLETON, *Agent.*

This pit, which is 100 fathoms in depth, is worked on what is called the Low Main seam, one mile north-east of Bedlington, and three miles west of the port of Blyth. The seam is 5 feet 6 inches in thickness, and tolerably regular, with a dip of 1¼ in. per yard 65° north of east. It is covered by two feet of blue shale, the other strata consisting of alternate layers of sandstone and schist. The coal is described by the agent as "very hard, easily ignited, and free burning, and leaving a white ash." The seam is worked by cutting out about a foot in thickness of its lower part, by means of picks, and then throwing down the upper portion by the use of wedges and mallets, gunpowder being sometimes employed to facilitate the operations. The coals are shipped at Blyth, where they are sold at *7s. 6d.* per ton, delivered on board ship, and are from thence largely exported to the continental markets, for steam-boat purposes, and for the generation of steam in general.

In appearance this coal resembles the other good Hartleys, being hard and bright, with but little shaly matter or iron pyrites. Under the boiler it lights easily, and burns freely, with the evolution of considerable quantities of smoke, and the formation of but little ash or clinker.

	February 15, 1st day.	February 16, 2nd day.
Fire lighted	9 h. 40 m.	10 h. 0 m.
Steam up	10 h. 0 m.	10 h. 25 m.
Weight of wood used	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	206°
Temperature of water in tanks	51°	44°
Barometer	30·60 in.	30·40 in.
Extremes of external thermometer	37°—55°	31°—45°
Extremes of internal thermometer	51°—60°	48°—58°
Dewpoint	43°	42°
Area of damper open	112 in.	56 in.
Weight of coal consumed	552 lbs.	483 lbs.
Weight of ashes left	10 lbs.	12 lbs.
Per centage of combustible matter in ashes	49·5	28·5
Weight of cinder left	12 lbs.	10 lbs.
Per centage of combustible matter in cinder	70·4	86·9
Weight of clinker in cinder	1 lb.	0·5 lb.
Average weight of soot in flues	·33 lbs.	·33 lb.
Per centage of combustible matter in soot	82·5	..
Weight of water evaporated	3860 lbs.	2950 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·11 lbs.	7·12 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·80 lbs.	12·07 lbs.
Duration of experiment	8 hrs.	8 hrs.
Specific gravity of coal	1·256	..
Mean weight of cubic foot of coal	47·74 lbs.	..
Economic weight or space occupied by 1 ton	46·96 ft.	..
Cohesive power of coal	76·5	..

Note.—Final temperature on third morning, 208°.

Cowpen and Sidney Hartley.

I HEREBY certify that the casks marked No. 3 C. H. contain a fair sample of the Cowpen and Sidney Hartley coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CHARLES CARR, *Proprietor.*

This coal is the produce of the Cowpen Colliery, in the township of Cowpen, parish of Woodhorn, county of Northumberland. This mine, like Davison's West Hartley, is on the Low Main Seam, the pits being situated at a distance of 13 miles N.E. of Newcastle, half a mile from the seaport town of Blyth, and 11 miles north of the river Tyne. To the two latter of which places the coals are conveyed by rail for shipment to the home and foreign markets. The present current price is 7*s.* per ton. The seam is worked at the depth of 110 fathoms from the surface, has a regular thickness of five feet; and being nearly horizontal, has no appreciable dip. The overlying and subjacent strata consist of various beds of shale and sandstone; and the manager describes the coal as "large, hard, and free burning; free from sulphur, and requiring but little stoking." He also adds, "it is highly-prized for steam purposes, and that 600 tons are daily raised from the mine, which yields employment to 540 men and boys."

In appearance this coal resembles the Davison's Hartley, being a bright splint, with a cubical fracture, and contains but little iron pyrites. Under the boiler it was found to behave precisely like the preceding, although it does not burn quite so freely.

—	February 19, 1st day.	February 20, 2nd day.	February 21, 3rd day.
Fire lighted	9 h. 25 m.	9 h. 10 m.	9 h. 55 m.
Steam up	10 h. 0 m.	9 h. 35 m.	10 h. 15 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	185°	209°	202°
Temperature of water in tanks	50°	48°	48°
Barometer	30·30 in.	29·85 in.	29·90 in.
Extremes of external thermometer	43°—51°	38°—52°	43°—53°
Extremes of internal thermometer	52°—57°	50°—57°	50°—58°
Dewpoint	42°	45°	44°
Area of damper open	112 in.	56 in.	84 in
Weight of coals consumed	568 lbs.	386 lbs.	494 lbs.
Weight of ashes left	13 lbs.	14 lbs.	14 lbs.
Per centage of combustible matter in ashes	19·8	76·1	65·0
Weight of cinder left	11 lbs.	13 lbs	15 lbs.
Per centage of combustible matter in cinder	79·12	66·6	48·9
Weight of clinker in cinder	1 lb.	0·75 lbs.	0·7 lbs.
Average weight of soot in flues	·5 lbs.	·5 lbs.	·5 lbs.
Per centage of combustible matter in soot	72·0	..	..
Weight of water evaporated	3350 lbs.	2200 lbs.	2860 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·11 lb.	6·7 lbs.	6·81 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·20 lbs.	9·65 lbs.	12·35 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·261	..	..
Mean weight of cubic foot of coal	47·91 lbs.	..	..
Economic weight or space occupied by 1 ton	46·76 ft.	..	..
Cohesive power of coal	74·0	..	..

Note.—Final temperature on fourth morning, 208°.

Nixon's Merthyr Coals.

I HEREBY certify that the six casks marked N. M. contain a fair sample of the Nixon's Merthyr coal, which was mined specially for the service of the "Admiralty Coals Investigation."—JOHN NIXON, *Proprietor.*

This coal-mine is situated on the Werra estate, near Merthyr Tydfil, and is worked on what is called the Upper Four-feet Seam, which varies from four to six feet in thickness, and has an inclination or dip of about one in ten towards the south. The roof of this vein is composed of sandstone and bituminous shale, whilst the bottom consists of fire-clay. The mine is worked by pillar and stall, and its present depth is 100 yards.

The shipping ports are Cardiff and Neath, from each of which towns the colliery is situated about 24 miles, and from whence the coals are exported to London, Liverpool, Southampton, France, Spain, and America. The current price of the Nixon's Merthyr is 10*s.* per ton, delivered on board ship; and it is described by the proprietor as "an open burning and nearly smokeless coal, little liable to deteriorate from exposure to the air."

The specimen examined at Putney College very closely resembled that from the Aberdare mines, except that it did not contain such large quantities of radiated semi-crystallized coal as the other varieties. Under the boiler this coal was found to light with difficulty, and to require a rather quick draught; it burns with a strong flame, and little or no smoke, leaving a considerable amount of ash, and but very little clinker. It is also liable to crumble on the fire, and fall through the bars; but, with a strong draught, it gives good results.

—	February 22, 1st day.	February 23, 2nd day.	February 24, 3rd day.
Fire lighted	9 h. 20 m.	9 h. 20 m.	9 h. 30 m.
Steam up	9 h. 45 m.	10 h. 10 m.	10 h. 10 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	208°	210°
Temperature of water in tanks	52°	48°	48°
Barometer	29·83 in.	29·8 in.	29·75 in.
Extremes of external thermometer	37°—56°	39°—49°	38°—50°
Extremes of internal thermometer	54°—58°	53°—60°	53°—58°
Dewpoint	50°	50°	49°
Area of damper open	112 in.	168 in.	84 in.
Weight of coals consumed	454 lbs.	479 lbs.	424 lbs.
Weight of ashes left	31 lbs.	35 lbs.	29 lbs.
Per centage of combustible matter in ashes	71·1	57·8	63·4
Weight of cinder left	16 lbs.	12 lb.	27 lbs.
Per centage of combustible matter in cinder	65·0	52·5	85·3
Weight of clinker in cinder	0·5 lb.	1 lb.	2 lbs.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3950 lbs.	4105 lbs.	3710 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	10·09 lbs.	9·98 lbs.	9·81 lbs.
Weight of coals per hour for 1 square foot of grate surface	11·35 lbs.	11·97 lbs.	12·11 lbs.
Duration of experiment	8 hrs.	8 hrs.	7 hrs.
Specific gravity of coal	1·319	..	..
Mean weight of cubic foot of coal	51·75 lbs.	..	..
Economic weight or space occupied by 1 ton	43·32 ft.	..	..
Cohesive power of coal	64·5	..	..

Note.—Final temperature on fourth morning, 185°.

Hill's Plymouth Works Steam Coals.

I HEREBY certify that the nine casks, shipped per "Enterprize" from Cardiff to London, contain a fair sample of the Hill's Plymouth Works Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—ANTHONY HILL, and GEORGE HEPPELL, *Proprietors.*

This coal is raised in the valley of the Taff, about three miles south of Merthyr Tydfil, Glamorganshire. The seam is called the Four-feet Vein, but is generally about 6 feet 10 inches in thickness, and tolerably regular, with a dip towards the south. The overlying strata are composed of "cliff," and the subjacent of hard fire clay. The mine is 112 yards deep, and is worked by stall and pillar.

The proprietors state that none of this coal has hitherto been sold, it having been exclusively employed for the manufacture of iron, for which purpose it is well adapted. It could, however, be brought to Cardiff, which is a distance of 21 miles from the mine, and sold at the ordinary price of coals shipped from that port, "say eight or nine shillings per ton," and as the vein exists under many hundreds of acres immediately contiguous to the spot from whence the specimen was taken, an indefinite supply may be obtained.

In appearance this coal differs from the last in being more granular in its structure, and containing no white shale in its cleavage. Mineralized charcoal was observed in small quantities, but not any iron pyrites.

Our experiments show that this coal does not light readily, and is rather bituminous, but when once a good fire is obtained the steam is blown off, steadily and rapidly, without the evolution of much smoke.

Like the preceding, it requires a strong draught, but does not contain so large an amount of incombustible matter.

—	February 26, 1st day.	February 27, 2nd day.	February 28, 3rd day.
Fire lighted	9h. 40 m.	9 h. 30 m.	9h. 20 m.
Steam up	10 h. 40 m.	9 h. 55 m.	10 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	185°	206°	206°
Temperature of water in tanks	44°	48°	48°
Barometer	29·85 in.	29·60 in.	29·33 in.
Extremes of external thermometer	31°—45°	35°—49°	33°—50°
Extremes of internal thermometer	51°—59°	51°—59°	51°—58°
Dewpoint	36°	39°·5	51°
Area of damper open	112 in.	168 in.	84 in.
Weight of coals consumed	463 lbs.	538 lbs.	481 lbs.
Weight of ashes left	14 lbs.	16 lbs.	17 lbs.
Per centage of combustible matter in ashes	58·1	52·3	55·8
Weight of cinder left	14 lbs.	15 lbs.	23 lbs.

	February 26, 1st day.	February 27, 2nd day.	February 28, 3rd day.
Per centage of combustible matter in cinder	72·1	82·5	67·6
Weight of clinker in cinder	2 lbs.	2 lbs.	1 lb.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	None.	..	..
Weight of water evaporated	3700 lbs.	4790 lbs.	4270 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·65 lbs.	10·37 lbs.	9·24 lbs.
Weight of coals per hour for 1 square foot of grate surface	11·57 lbs.	13·45 lbs.	12·02
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·359	..	..
Mean weight of cubic foot of coal	51·24 lbs.	..	..
Economic weight or space occupied by 1 ton	43·74 ft.	..	..
Cohesive power of coal	64·0	..	..

Note.—Final temperature on fourth morning, 208°.

Staveley Coals.

I HEREBY certify that the six casks marked S. contain a fair sample of the Staveley Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD BARROW, *Proprietor.*

This is called the "Top Hard" coal of Derbyshire, and is mined in the parish of Staveley, four miles N.E. of Chesterfield, in that county. The seam is perfectly regular, and six feet in thickness, with a dip of 1 in 8 towards the east. It is covered by hard clunch, or fire-clay, and lies on blue metal, locally called bind.

The coal is described by the proprietor as a "strong splint, which may be exposed for years to atmospheric influence without change or waste." He also adds, that the mine is worked by the "Long Wall" system, and that one foot of coal at the top of the seam is not worked out, but allowed to remain as a support to the overlying strata. The shipping ports are Gainsborough and Grimsby, from the former of which places the mine is distant 35, and from the latter 70 miles.

The coal is principally consumed in Derbyshire and Yorkshire, where it is used in the various stages of the iron manufacture, and is sold for 9*s.* per ton at the ports above named.

The specimen of this coal, which was sent up for examination, arrived partly in casks and partly in bulk, the blocks varying from 1 to 10 cwt. in weight. In structure these masses resembled silicified wood, but seem to have two distinct planes of cleavage at right angles to each other, which give the fragments the form of long four-sided prisms, which, when broken, give rise to splinters having the same shape.

In colour this coal is not so brilliant as the Hartleys, but, like them, contains white shale and small quantities of iron pyrites in the lines of cleavage.

Its cohesive power is higher than that of any other coal yet tried by the officers of this investigation, and from this circumstance, added to the natural facility afforded by its form, the proprietor suggests that it might be sawn into blocks for the convenience of stowage in steamers.

When tried under the boiler, these coals were found to light easily and burn freely, blowing off the steam with great rapidity, and yielding much smoke.

It was also observed that when a fresh charge was thrown on the fire a crackling was heard, occasioned by the scintillation of the coals.

They require to be stoked, like other splints, and burn to a white ash, which contains very little combustible matter.

	March 1, 1st day.	March 2, 2nd day.	March 3, 3rd day.
Fire lighted	9 h. 25 m.	9 h. 50 m.	9 h. 45 m.
Steam up	9 h. 40 m.	10 h. 35 m.	10 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	204°	208°
Temperature of water in tanks	46°	48°	50°
Barometer	30·00 in.	30·30 in.	30·08 in.
Extremes of external thermometer	40°—47°	42°—50°	40°—57°
Extremes of internal thermometer	51°—56°	58°—59°	56°—59°
Dewpoint	48°	48°	46°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	746 lbs.	492 lbs.	539 lbs.
Weight of ashes left	14 lbs.	9 lbs.	12 lbs.
Per centage of combustible matter in ashes	19·8	18·6	30·5
Weight of cinder left	12 lbs.	14 lbs.	14 lbs.
Per centage of combustible matter in cinder	74·1	66·3	74·2
Weight of clinker in cinder	4 lbs.	3 lbs.	3 lbs.
Average weight of soot in flues	·5 lbs.	·5 lbs.	·5 lbs.
Per centage of combustible matter in soot	67·9	..	..

	March 1, 1st day.	March 2, 2nd day.	March 3, 3rd day.
Weight of water evaporated	4535 lbs.	3060 lbs.	3600 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·05 lbs.	7·28 lbs.	7·37 lbs.
Weight of coals per hour for 1 square foot of grate surface	18·65 lbs.	12·30 lbs.	13·47 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·276	..	..
Mean weight of cubic foot of coal	49·91 lbs.	..	..
Economic weight or space occupied by 1 ton	44·48 ft.	..	..
Cohesive power of coal	88·5	..	..

Note.—Final temperature on fourth morning, 175°.

Andrew's House, Tanfield.

I HEREBY certify that the three casks marked Nos. 1, 2, 3, Andrew's House Colliery, contain a fair sample of the above coals, which were mined specially for the service of the "Admiralty Coals Investigation."—William Green, *Agent to the Northern Coal Mining Company.*

The Andrew's House Colliery is situated five miles south-west of Newcastle, in the parish of Tanfield, in the county of Durham, and is on the so-called main seam of that district, which is tolerably regular, and has a dip to the south-east. The overlying and subjacent strata consist of sandstone and black metal, together with various seams of coal, some of which are workable. The mine is 38 fathoms in depth, and is worked by the "board and pillar" system; it is 24 miles from South Shields, from whence the coal is chiefly exported to London for the manufacture of gas and for coke-making, at the current price of 5*s.* 6*d.* per ton on board ship.

The specimen of this coal which came into our hands arrived in such small pieces that its physical characters could not be easily examined; it, however, appeared to be bright, and to have a cubical fracture, free from shale and iron pyrites.

On the fire, this coal agglomerates and chokes the draught, requiring much care in stoking in order to keep up the steam, and appears much better adapted for coke-making than for steam purposes.

	March 5, 1st day.	March 6, 2nd day.	March 7, 3rd day.
Fire lighted	9 h. 45 m.	9 h. 20 m.	8 h. 30 m.
Steam up	10 h. 55 m.	9 h. 50 m.	8 h. 50 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	175°	204°	206°
Temperature of water in tanks	52°	54°	52°
Barometer	30·40 in.	30·52 in.	30·02 in.
Extremes of external thermometer	36°—55°	43°—55°	41°—54°
Extremes of internal thermometer	56°—62°	56°—63°	58°—63°
Dewpoint	44°	46°	47°
Area of damper open	112 in.	84 in.	56 in.
Weight of coals consumed	399 lbs.	334 lbs.	321 lbs.
Weight of ashes left	9 lbs.	12 lbs.	15 lbs.
Per centage of combustible matter in ashes	55·2	74·0	76·0
Weight of cinder left	8 lbs.	9 lbs.	7 lbs.
Per centage of combustible matter in cinder	70·4	79·8	85·0
Weight of clinker in cinder	1 lb.	·4 lbs.	·13 lbs.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	70·0	..	..
Weight of water evaporated	3150 lbs.	2850 lbs.	2430 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·58 lbs.	9·85 lbs.	8·74 lbs.
Weight of coals per hour for 1 square foot of grate surface	9·97 lbs.	8·35 lbs.	8·02 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·264	..	..
Mean weight of cubic foot of coal	52·16 lbs.	..	..
Economic weight or space occupied by 1 ton	42·99 ft.	..	..
Cohesive power of coal	..	..	..

Note.—Final temperature on fourth morning, 204°.

Experiments on the Relative Evaporative Power of the Tanfield Coke and the Coal from which it is manufactured.*

This coal is the produce of the Andrew's House Colliery, and has been above described under that name. The coke experimented on was manufactured from the above-mentioned

* In the experiment here detailed, the coke yields a less evaporative result than the coal from which it is made. It must not, however, be supposed that this experiment is at all decisive with regard to this point in the abstract; it is merely true with reference to the boiler and conditions of draught under which it was tried. No conclusions can be deduced from it as to the still undecided question—whether coke is equal in evaporative power to the quantity of coal from which it is produced.

coal by the Messrs. Cory of New Barge House Wharf, and by them sent to this place in large columnar masses, having a silvery white appearance, and apparently free from shale and earthy impurities. The coal is converted into coke, in ovens of the usual construction, and yields on an average 65 per cent. of coke of a good quality. In order to ascertain the actual quantity which this coal is capable of yielding, three experiments were made by putting a known weight in a small covered porcelain crucible, which being placed in an earthern one covered by charcoal in coarse powder, and again closed by an earthen stopper, was, in each case, exposed to a strong heat for an hour in an ordinary assaying furnace.

The charcoal dust in this arrangement protects the coal from the action of any unconsumed oxygen which may exist in the furnace, and, as results of the experiments, we obtained the following numbers:—

—	Weight of Coal Employed.	Weight of Coke Found.	Per Centage.
1st experiment .	166·5	108·8	65·34
2nd ,,	100·9	65·5	64·91
3rd ,,	129·4	84·3	65·14
			3)195·39
		Mean .	65·13

The above products, on being again strongly heated, sustained no further loss of weight, and a specimen of the coke experimented on, on being treated in the same way, was found to have lost but 0·2 per cent. of volatile matter: showing that but little loss had been sustained through the burning of fixed carbon, and that the process employed approached as nearly to perfection as can be hoped for in manufactures of this description.

It was found that one ton of this coal occupied 42·92 cubic feet, whilst the space required for the stowage of the same weight of coke is equal to 74·66 feet, giving a difference of 78 per cent. in favour of the coal. A great superiority in the evaporative power of a given bulk of this coal over the same amount of coke also becomes evident on consulting the working tables, which show that one cubic foot of coal evaporated during our experiments 516·90 lbs. of water from 212°, whilst the same bulk of coke gave 237·30 as its evaporating power.

The experiments in this case were conducted in the usual way, except that the ordinary draught not being sufficiently strong to obtain a good fire with the coke employed, it was increased by blowing off the steam into the chimney by means of a tube fitted to the apparatus for that purpose.

Each experiment was also made to occupy 34 hours, in order to avoid the inconvenience attending the lighting of the coke, if more numerous trials of the ordinary duration had been made.

In testing the evaporative power of the coke, it was found necessary to employ 50 lbs. of Hill's Plymouth Works coal for lighting the fire, in addition to the usual quantity of wood used for that purpose. Allowance for these was therefore made in the calculations, estimating 9·75 as the mean evaporating power of the former, and 3·09 as that of the latter. The initial temperature of the water contained in the boiler was in this experiment 203°, and the steam was got up 1¼ hour after firing, thus showing that the action of the coke was slow at the commencement, even when aided by the addition of the coals employed.

During the progress of the trial it was found necessary to heap the fuel more than was advisable for the economical consumption of the coke, as without doing so a sufficient mass of fire could not be obtained to keep up steady action; in order, however, to make the comparative trial as fair as possible, precisely the same method of stoking was adopted in the case of the coal.

At the close of the experiments it was found that 15,275 lbs. of water had been evaporated from 50° Faht., and 2184 lbs. of coke consumed after deducting for that which remained on the grate at the close of the trial, which gives 7·91 lbs. of water evaporated from 212° for each pound of coke employed. The clinker formed was very fusible, adhering firmly to the bars, and choking the draught. The total quantity of residual matter amounted to 5·4 per cent. of the weight of coke consumed.

COKE.

—	March 30 and 31.
Fire lighted	9 h. 0 m.
Steam up	10 h. 15 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	203°
Temperature of water in tanks	50° mean.
Barometer	29·65in.mean
Extremes of external thermometer	36°—56°

——	March 30 and 31.
Extremes of internal thermometer	52°—65°
Dewpoint	46° mean.
Area of damper open	168 in.
Weight of coke consumed	2184 lbs.
Weight of ashes left	94 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	None.
Per centage of combustible matter in cinder	..
Weight of clinker	25 lbs.
Average weight of soot in flues	None.
Per centage of combustible matter in soot	..
Weight of water evaporated	15,275 lbs.
Weight of water evaporated from 212° by 1 lb. of coke	7·91
Weight of coke per hour for 1 square foot of grate surface	12·84 lbs.
Duration of experiment	34 hrs.
Specific gravity of coke	..
Mean weight of cubic foot of coke	30·0 lbs.
Economic weight or space occupied by 1 ton	74·66 ft.
Cohesive power of coke	..

Note.—Final temperature, 192°.

The experiment on the Tanfield coals was carried on precisely as the preceding, the steam blowing off into the chimney at an average pressure of 3 lbs., and the stoking conducted as in the case of the coke.

During this trial 9·91 lbs. of water were evaporated from 212° for each pound of coal consumed; and at the close of the experiments a larger amount of clinker was found adhering to the bars than in the former case, occasioned by the greater intensity of the heat produced.

The residual matters remaining after the experiments amounted to 4·5 per cent. of the coal employed, or 0·9 per cent. less than the quantity obtained from the coke.

Coal.

——	April 2 and 3.
Fire lighted	10 h. 0 m.
Steam up	11 h. 0 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	192°
Temperature of water in tanks	50° mean.
Barometer	29·7 in. mean
Extremes of external thermometer	32°—56°
Extremes of internal thermometer	58°—68°
Dewpoint	48 mean.
Area of damper open	168 in.
Weight of coal consumed	2119 lbs.
Weight of ashes left	41 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	12 lbs.
Per centage of combustible matter in cinder	..
Weight of clinker in cinder	42 lbs.
Average weight of soot in flues	None.
Per centage of combustible matter in soot	..
Weight of water evaporated	17,895 lbs.
Weight of water evaporatated from 212° by 1 lb. of coal	9·91 lbs.
Weight of coal per hour for 1 square foot of grate surface	12·4 lbs.
Duration of experiment	34 hrs.
Specific gravity of coal	1·264
Mean weight of cubic foot of coal	52·1 lbs.
Economic weight or space occupied by 1 ton	42·99 ft.
Cohesive power of coal	..

Note.—Final temperature, 208°.

It may be seen from the foregoing tables that this coal has an evaporative power of 20·1 per cent. greater than the same weight of coke manufactured from it, and if in each case we deduct the incombustible matter contained in the fuel, we shall find the evaporating power of a unit of combustible matter in the coke to be 8·36, and that of the coal 10·39, or 19·3* per cent. more effective than a unit of the former.

The rapidity of action was also found to be in favour of the coal, as by it 526·3 lbs. of water were evaporated per hour; whilst the coke converted but 449·2 lbs. into steam in

* Professor Johnson found the unit of combustible matter contained in the coke from Neffs' Cumberland coal, to be 5·8 per cent. less effective than that of the coal itself. Vide *American Official Report on Coals*, p. 162.

the same time. The consumption of coke per hour was 66·2 lbs., and that of the coal 62·3 lbs., showing a difference of 2·9 per cent. in the hourly expenditure of fuel. This coal looses 35 per cent. of its weight in the process of coking, and gains 11·7 per cent. in volume during that operation; it also appears to yield the most satisfactory results with a quick draught, as the experiments made with the steam blowing off into the chimney gave an evaporative power 5½ per cent. higher than the mean of the preceding trials.

Cannel Coals.

I HEREBY certify that the three casks marked "Cannel" contain a fair sample of our Cannel coals, which were mined specially for the service of the "Admiralty Coals Investigation.—W. H. BRANCHER and Co., *Proprietors.*

This coal is raised at Walthen House, two miles from Wigan. The present depth of the mine is 292 yards where the seam is 2 feet 2 inches in thickness, with an inclination of from 1 in 15 to 1 in 20 towards the south, and is worked by the "board and wall" system. The subjacent and overlying strata consist of black stone and bass, which have the same inclination as the vein itself.

This coal has hitherto been exclusively employed for the manufacture of gas, with the exception of small quantities which are used for household purposes. The principal market is Liverpool, which is 33 miles distant from the mine, and to which place the coals are conveyed by the Leeds and Liverpool Canal, at a cost of 2*s.* 7½*d.* per ton.

Large quantities are also consumed at Manchester, and the other manufacturing towns of Lancashire and Cheshire; besides which, a considerable amount is annually exported to France, Russia, and America. The current price of small coal at the pit is 10*s.*, and of large 12*s.* per ton. In Liverpool, the small is sold for 14*s.*, and the large lumps for 18*s.* per ton. In appearance this resembles the ordinary cannel coals of the district, having a brownish black colour, with a resinous conchoidal fracture, and contains rather large quantities of iron pyrites and white shale.

Under the boiler, it was found to light readily, and get up the steam very quickly, but to evolve large quantities of dense black smoke during the whole time of experiment, and at the close, left a large amount of cinder and red ash, together with a considerable weight of a very fusible clinker which melted on the bars and obstructed the draught.

	April 9, 1st day.	April 10, 2nd day.	April 11, 3rd day.
Fire lighted	8 h. 45 m.	10 h. 0 m.	9 h. 30 m.
Steam up	9 h. 20 m.	10 h. 15 m.	9 h. 40 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	170°	204°	208°
Temperature of water in tanks	52°	50°	50°
Barometer	29·57 in.	29·65 in.	29·80 in.
Extremes of external thermometer	43°—53°	37°—50°	33°—49°
Extremes of internal thermometer	53°—58°	52°—57°	51°—57°
Dewpoint	48°	50°	49°
Area of damper open	112 in.	56 in.	56 in.
Weight of coals consumed	632 lbs.	367 lbs.	378 lbs.
Weight of ashes left	10 lbs.	13 lbs.	16 lbs.
Per centage of combustible matter in ashes	12·0	54·3	29·5
Weight of cinder left	31 lbs.	19 lbs.	6 lbs.
Per centage of combustible matter in cinder	82·2	80·2	74·7
Weight of clinker in cinder	8 lbs.	3 lbs.	2 lbs.
Average weight of soot in flues	1·3 lbs.	1·3 lbs.	1·3 lbs.
Per centage of combustible matter in soot	80·4	..	..
Weight of water evaporated	3485 lbs.	2750 lbs.	2530 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	6·71	8·76*	7·63
Weight of coals per hour for 1 square foot of grate surface	15·8 lbs.	3·17 lbs.	10·8 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·231	..	..
Mean weight of cubic foot of coal	4833 lbs.	..	..
Economic weight or space occupied by 1 ton	46·37 ft.	..	..
Cohesive power of coal	95·0	..	..

* In this experiment air was admitted behind the fire-bridge.
Note.—Final temperature on fourth morning, 202.

Litharge Experiments.

NAME OF COAL.	1st Experiment.	2nd Experiment.	3rd Experiment.	Mean.
Lyon's Patent Fuel	156·0	157·4	157·5	156·9
Wellewood, (No. 1.)	142·5	141·9	143·0	142·4
Wellewood, (No. 2.)	143·0	140·2	141·3	141·5
Eglinton	121·4	122·0	121·6	121·6
Neath Abbey	156·0	156·0	156·1	156·0
Blackbrook Rushy Park	152·5	151·0	152·0	151·8
Blackbrook Little Delf	144·5	143·0	142·7	143·4
Blackley Hurst	148·1	148·9	146·9	147·9
Johnson and Wirthington's Sir John	118·5	118·5	120·0	119·0
Johnson and Wirthington's Rushy Park	145·6	142·3	145·6	144·5
Laffak Rushy Park	133·3	134·0	136·0	134·4
Rushy Park Mine	146·9	144·0	144·0	144·9
Llynvi	161·5	161·0	161·3	161·2
Rock Vawr	143·6	145·3	144·9	144·6
Newcastle Hartley	159·0	159·0	159·9	159·3
Balcarres Lindsay	130·8	130·8	131·6	131·0
Balcarres Five-feet	132·1	130·5	127·0	129·8
Balcarres Haigh Yard	142·4	143·0	137·1	140·8
Conception Bay	128·0	126·5	130·0	128·1
Balcarres Arley	147·1	147·1	146·9	147·0
Carr's Hartley	153·7	154·0	156·0	154·5
North Percy Hartley	147·5	145·0	144·2	145·5
Hasting's Hartley	142·0	142·5	144·0	142·8
Hedley's Hartley	153·0	151·5	151·0	151·8
Original Hartley	132·9	133·0	133·5	133·1
Derwentwater's Hartley	145·9	145·0	145·6	145·5
Gadly Four-feet Seam	171·5	171·3	171·0	171·2
Gadly Nine-feet Seam	170·0	171·0	171·5	170·8
Aberdare Cos. Merthyr	170·0	171·3	170·6	170·6
Thomas's Merthyr	166·0	164·0	164·5	164·8
Buddle's West Hartley	147·1	149·0	147·0	147·7
Bate's West Hartley	144·0	144·7	145·1	144·6
Haswell Steam-boat Wallsend	144·0	143·9	144·1	144·0
Davison's West Hartley	149·0	151·0	152·0	150·6
Cowpen and Sidney Hartley	143·1	143·0	144·0	143·3
Nixon's Merthyr	166·0	166·2	166·0	166·0
Hill's Plymouth Work	169·4	169·6	172·0	170·3
Staveley	141·0	140·0	140·3	140·4
Andrews' House	155·0	155·2	155·9	155·3
Cannel (Wigan)	149·3	150·0	147·0	148·7

Note.—Weight of coal used in each experiment = 5 grains.

In the above table no correction has been made for the amount of sulphur contained in the coals, as in most cases the weight of lead reduced by the iron pyrites will be but from 0· to 0·19 per cent. of the total amount found; so that this quantity being smaller than the difference existing between the three successive experiments, it evidently comes within the limit of error, and may therefore be safely neglected.

If, however, it be desired to ascertain the reducing effect of the pyrites contained in any given coal, it may be obtained by multiplying the per centage of sulphur as found in Table II., by 0·77, and deducting the product from the mean amount of lead reduced by five grains of the coal.

Summary.

AME OF COAL.	Evaporative power, or number of pounds of Water evaporated from 212° by 1 lb. of Coal. — Practical.	Weight of one cubic foot of the Coal as used for Fuel.	Weight of one cubic foot of the Coal as calculated from the density.	Ratio of B. to C., or of the economic to the theoretical weights.	Difference per cent. between theoretical and economic weights.	Space occupied by 1 ton in cubic feet (economic weight).	Results of experiments on cohesive power of Coals (per centage of large Coals).	Evaporating power of Coals, after deducting for the Combustible matter in the residue.	Per centage of residue in the Coal. — Mean.	Weight of Water evaporated from 212° by 1 cubic foot	Pounds of clinker per ton of Coal.	Per centage amount of Coke.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.
ent Fuel	9·58	61·1	74·73	·817	22·30	36·66	..	9·77	6·06	585·33	38·7	..
. . . . .	8·24	52·6	79·78	·659	53·57	42·58	80·0	8·39	4·50	433·42	28·5	59·15
. . . . .	7·37	52·0	79·84	·651	51·48	43·07	79·5	7·48	4·03	383·24	8·2	54·94
ey	9·38	59·3	83·57	·709	40·92	37·77	50·0	9·65	5·44	556·23	19·2	61·42
: Rushy Park	8·02	55·3	80·15	·689	44·93	40·50	80·5	8·26	2·77	443·50	2·1	58·10
: Little Delf	8·29	51·0	78·16	·652	53·25	43·92	61·5	8·55	3·55	422·79	None.	58·48
Hurst	8·81	48·0	78·90	·608	64·37	46·66	65·0	9·00	3·74	422·88	12·2	57·84
d Wirthington's Sir John.	6·32	51·6	81·73	·631	58·39	43·41	82·0	6·62	9·42	326·11	34·4	56·15
nd Wirthington's Rushy	8·01	50·0	80·10	·624	60·20	44·80	69·0	8·16	3·64	400·50	8·6	57·52
hy Park	7·98	52·6	84·07	·625	59·82	42·58	75·5	8·16	3·78	419·74	5·1	56·26
k Mine.	8·08	47·0	80·04	·587	70·31	47·65	67·0	8·35	3·14	379·76	2 7	56·66
. . . . .	9·19	53·3	80·35	·663	50·56	42·02	..	9·58	9·07	489·82	36·0	72·94
r	7·68	55·0	80·21	·685	45·83	40·72	65·5	7·88	5·92	422·40	38·0	62·50
Hartley	8·23	50·5	80·27	·629	58·95	44·35	78·5	8·65	8·07	415·61	17·0	64·61
Lindsay Mine	7·44	51·1	78·61	·650	53·83	43·83	70·0	7·58	4·93	3·0·18	22·3	57·84
Five-feet Mine	7·21	49·0	79·11	·619	61·44	45·71	44·5	7·35	4·77	353·29	21·8	55·90
Haigh Yard	7·90	50·8	80·10	·634	57·67	44·13	80·0	8·23	8·34	401·32	26·4	66·09
Bay	5·72	..	80·54	..	..	..	..	5·96	8·48	..	44·5	43·63
Arley Mine.	8·83	50·5	78·17	·646	54·79	44·35	76·0	9·09	5·68	445·91	11·0	62·89
ley	7·71	47·8	78·23	·611	63·66	46·86	77·5	8·13	5·76	368·53	5·0	60·63
y Hartley	7·57	49·1	78·29	·627	59·45	45·62	60·0	7·72	4·86	371·68	7·8	57·18
Hartley	7·77	48·5	78·04	·621	60·90	46·18	75·5	7·96	4·59	376·84	1·7	35·60
Hartley	8·16	52·0	81·79	·635	57·28	43·07	85·5	8·71	11·89	424·32	14·4	72·31
artley	6·82	49·1	77·98	·629	58·81	45·62	80·0	6·98	4·27	334·86	10·1	58·22
ter's Hartley	7·42	50·4	78·79	·639	56·32	41·44	63·5	7·66	6·38	373·96	28·3	54·83
r-feet seam.	9·29	51·6	82·79	·623	60·44	43·41	68·5	10·73	20·54	479·36	11·6	88·23
e-feet seam.	9·56	54·8	83·16	·658	51·75	40·87	76·0	10·46	17·05	523·88	6·0	86·54
Coal Company's Merthyr .	9·73	49·3	81·73	·603	65·78	45·43	74·5	10·27	8·38	479·68	9·8	85·83
Merthyr	10·16	53·0	82·29	·644	55·26	42·26	57·5	10·72	9·03	538·48	3·9	86·53
West Hartley	7·82	50·6	77·11	·656	52·39	44·09	80·0	8·01	4·82	395·19	5·9	57·59
t Hartley	8·04	50·8	78·17	·649	53·87	44·13	69·5	8·26	4·48	408·43	1·4	57·31
oal Company's Steam-boat d.	7·48	49·5	79·36	·623	60·32	45·25	79·5	7·85	10·45	370·66	9·8	61·38
West Hartley	7·61	47·7	78·36	·608	64·27	46·96	76·5	7·83	4·47	362·99	2·1	59·49
nd Sydney Hartley. . .	6·79	47·9	78·67	·608	64·23	46·76	74·0	7·02	5·69	325·24	3·7	58·59
erthyr	9·96	51·7	82·29	·628	59·16	43·32	64·5	10·70	11·31	514·93	5·7	79·11
mouth Work	9·75	51·2	84·78	·603	65·68	43·74	64·0	10·18	7·01	499·20	7·5	82·25
. . . . .	7·26	49·9	79·79	·625	59·90	44·88	88·5	7·40	4·78	362·27	12·6	37·86
House (Tanfield) . . .	9·39	52·1	78·86	·660	51·36	42·99	..	9·80	5·83	489·21	3·2	65·13
Wigan)	7·70	48·3	76·80	·628	59·00	46·37	95·0	8·06	7·84	371·91	21·1	60·33

Analyses of Coals, by H. How and T. T. Philipps.

Experimental Numbers found in Analyses.

Lyon's Patent Fuel.

This coal contained 1·91 per cent. water: dried at 212° Fah.

Coal.			
3·445	grs. gave	10·885	carbonic acid and 1·515 water.
4·197	,,	13·322	,, 1·605 ,,
8·685	,,	0·045	ash.
10·505	,,	0·490	,,
13·040	,,	2·225	chloride of platinum and ammonium.
13·380	,,	1·350	sulphate of baryta.

Wellewood.

This coal contained 2·77 per cent. water: dried at 212° Fah.

Coal.			
3·140	grs. gave	9·358	carbonic acid.
3·255	,,	9·720	,, and 1·855 water.
6·145	,,	0·180	ash.
9·060	,,	0·260	,,
12·490	,,	3·060	platinum salt.
8·255	,,	0·990	sulphate of baryta.

Ash reddish grey.

Eglinton.

This coal contained 10·02 per cent. water: dried at 212° Fah.

Coal.			
3·550	grs. gave	10·43	carbonic acid and 2·05 water.
3·373	,,	9·90	,, 2·00 ,,
8·330	,,	0·21	ash.
6·760	,,	0·16	,,
12·405	,,	3·00	platinum salt.
9·640	,,	1·01	sulphate of baryta.

Ash white.

Neath Abbey.

This coal contained 1·02 per cent. water: dried at 212° Fah.

Coal.			
3·215	grs. gave	10·51	carbonic acid and 1·455 water.
3·290	,,	10·73	,, 1·505 ,,
8·685	,,	0·31	ash.
8·605	,,	0·305	,,
9·785	,,	1·680	platinum salt.
11·960	,,	1·460	sulphate of baryta.

Ash redish yellow.

Blackbrook Rushy Park.

This coal contained 5.90 per cent. water: dried at 212° Fah.

Coal.			
3·320	grs. gave	9·880	carbonic acid and 1·775 water.
3·305	,,		,, 1·800 ,,
7·100	,,	0·185	ash.
6·690	,,	0·185	,,
11·750	,,	2·530	platinum salt.
10·380	,,	1·280	sulphate of baryta.

Ash grey.

Blackbrook Little Delf.

This coal contained 5·58 per cent. water: dried at 212° Fah.

Coal.			
3·195	grs. gave	9·71	carbonic acid and 1·60 water.
3·230	,,	9·775	,, 1·61 ,,
6·015	,,	0·270	ash.
6·775	,,	0·280	,,
9·315	,,	2·200	platinum salt.
10·360	,,	0·890	sulphate of baryta.

Ash reddish white.

BLACKLEY HURST.

This coal contained 3·66 per cent. water: dried at 212° Fah.

Coal.					
3·120	grs.	gave	9·39	carbonic acid and	1·60 water.
2·975	,,		8·94	,,	1·45 ,,
6·410	,,		0·265 ash.		
5·790	,,		0·230 ,,		
11.645	,,		3·125 platinum salt.		
11·680	,,		1·300 sulphate of baryta.		

Ash reddish grey.

JOHNSON AND WIRTHINGTON'S SIR JOHN.

This coal contained 4·62 per cent. water: dried at 212° Fah.

Coal.					
3·11	grs.	gave	8·295	carbonic acid and	1·395 water.
3·04	,,		8·135	,,	
5·375	,,		0·610 ash.		
6·760	,,		0·775 ,,		
14·335	,,		2·465 platinum salt.		
11·575	,,		1·490 sulphate of baryta.		

Ash grey.

JOHNSON AND WIRTHINGTON'S RUSHY PARK.

This coal contained 7·15 per cent. water: dried at 212° Fah.

Coal.					
3·330	grs.	gave	9·710	carbonic acid and	1·545 water.
3·210	,,		9·355	,,	1·490 ,,
7·820	,,		0·170 ash.		
7·185	,,		0·160 ,,		
16·810	,,		3·240 platinum salt.		
11·650	,,		2·360 sulphate of baryta.		

Ash reddish grey.

LAFFAK RUSHY PARK.

This coal contained 6·24 per cent. water: dried at 212° Fah.

Coal.					
3·55	grs.	gave	10·47	carbonic acid and	1·83 water.
3·41	,,		10·54	,,	1·76 ,,
7·46	,,		0·21 ash.		
10·71	,,		0·31 ,,		
14·26	,,		2·90 platinum salt.		
12·71	,,		1·30 sulphate of baryta.		

Ash pink.

RUSHY PARK MINE.

This coal contained 11·66 per cent. water: dried at 212° Fah.

Coal.					
3·610	grs.	gave	10·280	carbonic acid and	1·715 water.
3·700	,,		10·565	,,	1·73 ,,
7·395	,,		0·415 ash.		
9·270	,,		0·535 ,,		
13·460	,,		2·670 platinum salt.		
12·885	,,		1·055 sulphate of baryta.		

Ash reddish grey.

LLYNVI.

This coal contained 1·13 per cent. water: dried at 212° Fah.

Coal.					
3·315	grs.	gave	10·565	carbonic acid and	1·43 water.
2·950	,,		9·460	,,	1·42 ,,
8·190	,,		0·250 ash.		
6·230	,,		0·190 ,,		
11·815	,,		1·630 platinum salt.		
10·700	,,		1·075 sulphate of baryta.		

ROCK VAWR.

This coal contained 2·33 per cent. water: dried at 212° Fah.

Coal.					
3·27	grs.	gave	9·37	carbonic acid and	1·265 water.
3·07	,,		8·76	,,	1·245 ,,
8·61	,,		0·655 ash.		
8·12	,,		·610 ,,		
11·97	,,		1·100 platinum salt.		
10·56	,,		0·860 sulphate of baryta.		

Ash pink.

NEWCASTLE HARTLEY.

This coal contained 1·38 per cent. water. : dried at 212° Fah.

Coal.				
3·32	grs. gave	9·98	carbonic acid and	1·67 water.
3·54	,,	10·60	,,	1·73 ,,
7·415	,,	·52	ash	
5·900	,,	0·43	,,	
12·870	,,	2·64	platinum salt.	
11·190	,,	1·43	sulphate of baryta.	

Ash grey.

BALCARRES LINDSAY.

This coal contained 6·47 per cent. of water: dried at 212° Fah.

Coal.				
3·43	grs. gave	10·57	carbonic acid and	1·775 water.
3·295	,,	10·12	,,	1·166 ,,
9·540	,,	0·19	ash.	
9·000	,,	0·18	,,	
13·170	,,	2·95	platinum salt.	
12·450	,,	1·47	sulphate of baryta.	

BALCARRES FIVE FEET MINE.

This coal contained 7·12 per cent. water: dried at 212° Fah.

Coal.				
3·46	grs. gave	9·39	carbonic acid and	1·60 water.
3 445	,,	9·40	,,	1·53 ,,
7·975	,,	0·75	ash.	
6·09	,,	0·55	,,	
14·84	,,	1·83	platinum salt.	
12·10	,,	2·0	sulphate of baryta.	

Ash grey.

BALCARRES HAIGH YARD MINE.

This coal contained 2·69 per cent. water: dried at 212° Fah.

Coal.				
3·57	grs. gave	10·74	carbonic acid and	1·785 water.
3·63	,,	10·98	,,	1·765 ,,
12·25	,,	0·48	ash.	
13·62	,,	0·53	,,	
12·61	,,	2·53	platinum salt.	
12·90	,,	1·46	sulphate of baryta.	

Ash had a reddish colour.

CONCEPTION BAY, CHILI.

This coal contained 13·52 per cent. water: dried at 212° Fah.

Coal.				
3·645	grs. gave	9·40	carbonic acid and	1·865 water.
3·480	,,	9·03	,,	1·825 ,,
4·960	,,	0·375	ash.	
6·140	,,	0·460	,,	
17·060	,,	2·590	platinum salt.	
10·625	,,	1·720	sulphate of baryta.	
13·330	,,	1·990	,,	

Ash grey.

BALCARRES ARLEY.

This coal contained 1·86 per cent. water: dried at 212° Fah.

Coal.				
3·455	grs. gave	10·550	carbonic acid and	1·595 water.
3·290	,,	10·110	,,	1·585 ,,
11·370	,,	0·370	ash.	
13·540	,,	0·460	,,	
12·300	,,	1·920	platinum salt.	
14·080	,,	1·140	sulphate of baryta.	

This coal swells on igniting, and leaves a brown ash.

CARR'S HARTLEY.

This coal contained 5·60 per cent. water: dried at 212° Fah.

Coal.				
3·455	grs. gave	10·165	carbonic acid and	1·610 water.
4.125	,,	12·015	,,	1·875 ,,
13·040	,,	0·680	ash.	
10·550	,,	0·550	,,	
12·350	,,	2·310	platinum salt.	
13·590	,,	0·915	sulphate of baryta.	

This coal gave much smoke on heating, and left a white ash.

North Percy Hartley.

This coal contained 8·41 per cent. water: dried at 212° Fah.

Coal.				
3·250	grs.	gave	9·51	carbonic acid and 1·525 water.
3·468	,,		10·208	,, 1·545 ,,
18·200	,,		0·580	ash.
12·890	,,		0·420	,,
15·000	,,		2·370	platinum salt.
12·190	,,		0·750	sulphate of baryta.

Burns with much smoke. Ash, pink.

Hasting's Hartley.

This coal contained 7·88 per cent. water: dried at 212° Fah.

Coal.				
3·523	grs.	gave	10·605	carbonic acid and 1·685 water.
3·505	,,		10·590	,, 1·750 ,,
9·790	,,		0·270	ash.
10·710	,,		0·335	,,
14·850	,,		3·820	platinum salt.
14·200	,,		1·470	sulphate of baryta.

Burns with much smoke, but without intumescence. Ash, pink.

Hedley's Hartley.

This coal contained 1·46 per cent. water: dried at 212° Fah.

Coal.				
3·143	grs.	gave	9·250	carbonic acid and 1·435 water.
3·215	,,			,, 1·59 ,,
9·515	,,		0·865	ash.
10·750	,,		0·985	,,
13·240	,,		2·460	platinum salt.
12·610	,,		1·810	sulphate of baryta.

Swells on ignition, gives much smoke; ash of a grey colour.

Original Hartley.

This coal contained 8·11 per cent. water: dried at 212° Fah.

Coal.				
3·085	grs.	gave	9·22	carbonic acid and 1·52 water.
3·114	,,		9·265	,, 1·585 ,,
10·700	,,		0·335	ash.
10·587	,,		0·320	,,
15·320	,,		1·770	platinum salt.
14·245	,,		1·565	sulphate of baryta.

Ash pink.

Derwentwater's Hartley.

This coal contained 12·52 per cent. water: dried at 212° Fah.

Coal.				
3·820	grs.	gave	10·937	carbonic acid and 1·610 water.
3·415	,,		9·760	,, 1·420 ,,
14·930	,,		0·560	ash.
12·630	,,		0·470	,,
7·740	,,		2·280	platinum salt.
15·645	,,		1·650	sulphate of baryta.

Ash pinkish brown.

Gadly Four-Feet Seam.

This coal contained 1·24 per cent. water: dried at 212° Fah.

Coal.				
5·205	grs.	gave	16·82	carbonic acid and 2·042 water.
3·610	,,		11·78	,, 1·665 ,,
10·400	,,		0·51	ash.
10·280	,,		0·50	,,
15·575	,,		2·20	platinum salt.
16·520	,,		1·46	sulphate of baryta.
13·305	,,		1·14	,,

Ash greyish brown.

GADLY NINE-FEET SEAM.

This coal contained 1·44 per cent. water: dried at 212° Fah.

Coal.				
3·720	grs. gave	11·705	carbonic acid and	1·360 water.
4·197	,,	13·322	,,	1·660 ,,
12·390	,,	0·680 ash.		
11·425	,,	0·595 ,,		
16·630	,,	2·890 platinum salt.		
14·380	,,	1·020 sulphate of baryta.		

Ash greyish pink.

ABERDARE COMPANY'S MERTHYR.

This coal contained 1·40 per cent. water: dried at 212° Fah.

Coal.				
3·813	grs. gave	12·38	carbonic acid and	1·43 water.
3·870	,,	12·49	,,	1·51 ,,
9·030	,,	0·295 ash.		
11·140	,,	0·365 ,,		
13·200	,,	3·510 platinum salt.		
13·160	.,	0·935 sulphate of baryta.		

Ash white.

THOMAS'S MERTHYR.

This coal contained 1·42 per cent. water: dried at 212° Fah.

Coal.				
3·152	grs. gave	10·44	carbonic acid and	1·205 water.
3·043	,,	10·03	,,	1·215 ,,
8·560	,,	0·15 ash.		
12·930	,,	0·21 ,,		
12·260	,,	1·96 platinum salt.		
11·840	,,	0·76 sulphate of baryta.		

Ash pinkish white.

BUDDLE'S WEST HARTLEY.

This coal contained 7·24 per cent. water: dried at 212° Fah.

Coal.				
3·495	grs. gave	10·35	carbonic acid and	1·57 water.
3·570	,,	10·57	,,	1·635 ,,
8·570	,,	0·33 ash.		
7·920	,,	0·305 ,,		
13·230	,,	3·080 platinum salt.		
14·495	,,	1·180 sulphate of baryta.		

BATE'S WEST HARTLEY.

This coal contained 9·28 per cent. water; dried at 212° Fah.

Coal.				
3·565	grs. gave	10·57	carbonic acid and	1·685 water.
3·790	,,	11·17	,,	1·775 ,,
14·320	,,	0·603 ash.		
11·120	,,	0·478 ,,		
15·000	,,	3·635 platinum salt.		
11·670	,,	1·650 sulphate of baryta.		

HASWELL COAL COMPANY'S STEAMBOAT WALLSEND.

This coal contained 1·14 per cent. water: dried at 212° Fah.

Coal.				
3·820	grs. gave	11·76	carbonic acid and	1·86 water.
3·545	,,	10·85	,,	1·66 ,,
10·235	,,	0·61 ash.		
10·720	,,	0·635 ,,		
15·035	,,	2·555 platinum salt.		
13·920	,,	1·350 sulphate of baryta.		

DAVISON'S WEST HARTLEY.

This coal contained 6·19 per cent. water: dried at 212° Fah.

Coal.				
3·570	grs. gave	10·90	carbonic acid and	1·70 water.
3·895	,,	,,		1·87 ,,
10·710	.,	0·64 ash.		
12·510	,,	0·715 ,,		
14·350	,,	3·950 platinum salt.		
13·455	,,	1·490 sulphate of baryta.		

Swells when heated, gives much smoke, and leaves a greyish red ash.

COWPEN AND SIDNEY HARTLEY

This coal contained 10·17 per cent. water: dried at 212° Fah.

Coal.			
3·471	grs. gave	10·435 carbonic acid and	1·57 water.
3·443	,,	10·405 ,,	1·60 ,,
11·160	,,	0·270 ash.	
7·590	,,	0·170 ,,	
11·790	,,	3·180 platinum salt.	
10·730	,,	0·590 sulphate of baryta.	

Burns without swelling; ash brown.

NIXON'S MERTHYR.

This coal contained 1·22 per cent. water: dried at 212° Fah.

Coal.			
3·512	grs. gave	11·65 carbonic acid and	1·29 water.
2·800	,,	9·25 ,,	1·05 ,,
13·705	,,	0·175 ash.	
15·725	,,	0·195 ,,	
13·570	,,	1·360 platinum salt.	
14·090	,,	1·260 sulphate of baryta.	

HILL'S PLYMOUTH WORK.

This coal contained 1·26 per cent. water: dried at 212° Fah.

Coal.			
3·750	grs. gave	12·19 carbonic acid and	1·38 water.
3·552	,,	11·505 ,,	1·255 ,,
13·160	,,	0·470 ash.	
13·110	,,	0·475 ,,	
12·370	,,	0·910 platinum salt.	
10·250	,,	0·680 sulphate of baryta.	

Ash pink.

STAVELEY.

This coal contained 8·54 per cent. water: dried at 212° Fah.

Coal.			
3·530	grs. gave	10·300 carbonic acid and	1·54 water.
5·415	,,	10·035 ,,	1·49 ,,
9·480	,,	0·230 ash.	
10·430	,,	0·250 ,,	
11·700	,,	2·300 platinum salt.	
11·685	,,	0·650 sulphate of baryta.	

Ash fawn colour.

ANDREW'S HOUSE, TANFIELD.

This coal contained 6·58 per cent. water: dried at 212° Fah.

Coal.			
3·467	grs. gave	10·902 carbonic acid and	1·68 water.
3·160	,,	9·897 ,,	1·49 ,,
18·100	,,	0·380 ash.	
13·670	,,	0·300 ,,	
14·150	,,	2·850 platinum salt.	
14·290	,,	1·420 sulphate of baryta.	

Ash reddish.

CANNEL COAL, WALTHEN HOUSE, NEAR WIGAN.

This coal contained 1·01 per cent. water: dried at 212° Fah.

Coal.			
3·925	grs. gave	11·585 carbonic acid and	2·115 water.
3·570	,,	12·205 ,,	1·990 ,,
15·850	,,	0·755 ash.	
9·110	,,	0·450 ,,	
10·750	,,	2·020 platinum salt.	
11·140	,,	1·240 sulphate of baryta.	

Ash sandy colour.

COAL FROM SYDNEY, NEW SOUTH WALES.

This coal contained 3·25 per cent. water: dried at 212° Fah.

Coal.			
3·75	grs. gave	11·31 carbonic acid.	
3·32	,,	10·05 ,,	and 1·59 water.
9·13	,,	0·19 ash.	
10·00	,,	0·20 ,,	
8·88	,,	1·75 platinum salt.	
9·88	,,	0·534 sulphate of baryta.	

Ash white.

COAL FROM PORT FAMINE, STRAITS OF MAGELLAN.

This coal contained 14·63 per cent. water: dried at 212° Fah.

Coal.			
4·13	grs. gave	9·75 carbonic acid, and	2·00 water.
2·88	,,	6·76 ,,	1·37 ,,
5·45	,,	0·34 ash.	
7·58	,,	0·47 ,,	
13·97	,,	1·12 platinum salt.	
9·73	,,	0·82 sulphate of baryta.	

Ash yellow.

COAL FROM CHIRIQUE.

This coal contained 9·11 per cent. water: dried at 212° Fah.

Coal.			
4·18	grs. gave	6·03 carbonic acid, and	1·58 water.
4·34	,,	6·15 ,,	
9·45	,,	3·47 ash.	
7·65	,,	2·84 ,,	
11·44	,,	1·06 platinum salt.	
10·66	,,	4·78 sulphate of baryta.	

Ash reddish yellow.

COAL FROM LAREDO BAY, SOUTH OF ELIZABETH ISLAND, NEAR THE SECOND NARROWS, STRAITS OF MAGELLAN.

This coal contained 16·03 per cent. water: dried at 212° Fah.

Coal.			
3·78	grs. gave	8·16 carbonic acid, and	1·98 water.
3·65	,,	7·83 ,,	1·72 ,,
11·14	,,	1·83 ash.	
6·29	,,	1·06 ,,	
11·80	,,	1·34 platinum salt.	
10·84	,,	1·17 sulphate of baryta.	

COAL FROM SANDY BAY, PATAGONIA.

Specimen 1.

This coal contained 22·68 per cent. water: dried at 212° Fah.

Coal.			
4·33	grs. gave	9·875 carbonic acid, and	1·980 water.
4·29	,,	9·80 ,,	1·950 ,,
10·80	,,	1·46 ash.	
12·94	,,	1·72 ,,	
20·94	,,	2·12 platinum salt.	
13·46	,,	1·39 sulphate of baryta.	

Specimen 2.

This coal contained 22·26 per cent. water: dried at 212° Fah.

Coal.			
4·39	grs. gave	9·58 carbonic acid, and	2·235 water.
3·97	,,	8·70 ,,	2·045 ,,
10·55	,,	1·65 ash.	
11·30	,,	1·77 ,,	
19·07	,,	1·96 platinum salt.	
13 54	,,	1·255 sulphate of baryta.	

TALCAHNANO BAY, NEAR CONCEPTION, CHILI.

This coal contained 12·43 per cent. water: dried at 212° Fah.

Coal.			
4·265	grs. yielded	11·09 carbonic acid, and	2·565 water
3·415	,,	8·83 ,,	1·900 ,,
9·115	,,	0·635 ash.	
10·380	,,	0·715 ,,	
15·750	,,	2·720 platinum salt.	
13·190	,,	1·050 sulphate of baryta.	

Ash grey.

VANCOUVER'S ISLAND.

This coal contained 7·21 per cent. water: dried at 212° Fah.

Coal.			
3·585	grs. yielded	8·775 carbonic acid, and	1·68 water.
4·010	,,	9·870 ,,	1·97 ,,
14·745	,,	2·355 ash.	
12·295	,,	1·930 ,,	
18·330	,,	3·000 platinum salt.	
11·030	,,	2·020 sulphate of baryta.	

Ash grey.

COAL FROM COLCURRA BAY, NEAR CONCEPTION, CHILI.

This coal contained 5·89 per cent. water: dried at 212° Fah.

Coal.			
3·39	grs. yielded	9·75	carbonic acid, and 1·70 water.
3·24	,,	9·28	,, 1·58 ,,
12·84	,,	0·72	ash.
9·20	,,	0·53	,,
15·78	,,	2·74	platinum salt.
11·23	,,	0·98	sulphate of baryta.

Ash of a reddish colour.

TABLE showing the per centage composition of the Coals analysed, calculated from the numbers before given.

Name or Locality.	Carbon.		Hydrogen.		Ash.		Sulphur.	Nitrogen.
	I.	II.	I.	II.	II.	II.		
Lyon's Patent Fuel	86·17	86·56	4·88	4·25	4·66	4·66	1·29	1·06
Wellewood	81·44	81·27	6·33	6·24	2·92	2·86	1·57	1·53
Eglinton	80·12	80·04	6·41	6·58	2·52	2·36	1·38	1·55
Neath Abbey	89·15	88·94	5·02	5·08	3·56	3·54	1·60	1·07
Blackbrook Rushy Park	81·16	..	5·83	6·05	2·60	2·76	1·62	1·35
Blackbrook Little Delf	82·88	82·53	5·56	5·53	4·48	4·14	1·06	1·48
Blackley Hurst	82·08	81·95	5·69	5·41	4·13	3·97	1·43	1·68
Johnson and Wirthington's Sir John	72·74	72·98	4·98	..	11·34	11·46	1·54	1·07
Johnson and Wirthington's Rushy Park	79·52	79·48	5·15	5·15	2·17	2·22	2·71	1·21
Laffak Rushy Park	80·43	80·51	5·72	5·73	2·81	2·83	1·39	1·27
Rushy Park Mine	77·66	77·87	5·27	5·19	5·77	5·61	1·01	1·32
Llynvi	86·91	87·45	4·79	5·34	3·05	3·04	1·30	0·86
Rock Vawr	78·14	77·82	4·29	4·50	7·60	7·51	0·96	0·57
Newcastle Hartley	81·98	81·65	5·58	5·43	7·01	7·28	1·69	1·28
Balcarres Lindsay	84·04	83·76	5·74	5·59	1·99	2·00	1·51	1·40
Balcarres Five-Feet	74·01	74·41	5·13	4·93	9·40	9·03	1·10	0·77
Balcarres Haigh Yard	82·04	82·49	5·55	5·40	3·91	3·89	1·48	1·25
Conception Bay	70·33	70·77	5·68	5·84	7·56	7·49	1·90	0·95
Balcarres Arley	83·28	83·80	5·13	5·35	3·25	3·39	1·11	0·98
Carr's Hartley	80·23	79·43	5·18	5·04	5·21	5·21	0·82	1·17
North Percy Hartley	79·80	80·27	5·21	4·95	3·18	3·26	0·78	0·98
Hasting's Hartley	82·09	82·40	5·31	5·54	2·75	3·12	1·35	1·61
Hedley's Hartley	80·26	..	5·07	5·49	9·09	9·16	1·78	1·16
Original Hartley	81·23	81·14	5·47	5·65	3·13	3·02	1·44	0·72
Derwentwater's Hartley	78·08	77·94	4·62	4·68	3·75	3·72	1·37	1·84
Gadly Four-Feet Seam	88·13	88·99	4·36	5·12	4·90	4·86	1·12	0·88
Gadly Nine-Feet Seam	85·81	86·56	4·39	4·24	5·48	5·20	0·87	1·09
Aberdare Company's Merthyr	88·54	88·02	4·16	4·33	3·26	3·27	0·91	1·66
Thomas's Merthyr	90·33	89·91	4·24	4·43	1·75	1·62	0·85	1·00
Buddle's West Hartley	80·76	80·74	4·99	5·08	3·85	3·85	1·04	1·46
Bate's West Hartley	80·86	80·37	5·27	5·25	4·21	4·29	1·85	1·52
Haswell Coal Company's Steam-boat, Wallsend	83·96	83·57	5·41	5·20	5·95	5·92	1·21	1·06
Davison's West Hartley	83·26	..	5·28	5·33	5·97	5·71	1·38	1·72
Cowpen and Sidney Hartley	81·99	82·41	5·04	5·16	2·42	2·24	0·71	1·69
Nixon's Merthyr	90·46	90·09	4·08	4·16	1·27	1·24	1·20	0·63
Hill's Plymouth Work	88·65	88·33	4·08	3·93	3·57	3·62	0·84	0·46
Staveley	79·57	80·14	4·84	4·84	2·42	2·39	0·72	1·23
Andrew's House (Tanfield)	85·75	85·41	5·38	5·25	2·09	2·19	1·32	1·26
Cannel (Wigan)	80·49	17·98	5·98	6·19	4·76	4·93	1·43	1·18
Sydney, N. S. W.	82·24	82·54	..	5·32	2·08	2·00	0·70	1·23
Port Famine	64·37	64·00	5·38	5·28	6·23	6·20	1·03	0·50
Chirique	38·64	39·33	3·83	4·19	36·71	37·12	6·14	0·58
Laredo Bay	58·86	58·49	5·81	5·23	16·42	16·85	1·14	0·71
Sandy Bay (Patagonia), No. I.	62·19	62·30	5·08	5·03	13·29	13·51	1·13	0·63
Sandy Bay (Patagonia), No. II.	59·51	59·76	5·65	5·72	15·63	15·66	0·96	0·64
Talcahnano Bay	70·91	70·51	6·68	6·20	6·88	6·96	0·94	1·08
Vancouver's Island	66.75	67·12	5·20	5·45	15·97	15·69	2·20	1·02
Colcurra Bay (Chili)	78·43	78·18	5·59	5·41	5·60	5·76	1·06	1·09

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MUSEUM OF PRACTICAL GEOLOGY.

THIRD REPORT

ON THE

COALS SUITED TO THE STEAM NAVY.

BY

SIR HENRY DE LA BECHE, C.B., F.R.S.,

AND

DR. LYON PLAYFAIR, F.R.S.

Presented to both Houses of Parliament by Command of Her Majesty.

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FOR HER MAJESTY'S STATIONERY OFFICE.

1851.

THIRD REPORT.

TO THE RIGHT HONOURABLE LORD SEYMOUR.

Museum of Practical Geology,
2nd April, 1851.

My Lord,

We have now the honour to present our Third and last Report on the value of different varieties of British Coals for the purposes of the Naval Service. The methods employed in testing the evaporative value of the coals, and of identifying their character by chemical analysis, have already been fully described in the two previous Reports. In the present examination the same endeavours have been used to give rather a practical than a scientific character to the experiments. The coals have in all cases been burned with varying draughts of air, in three successive experiments, for the purpose of eliciting the conditions most favourable to their combustion; and the mean of the three experiments is supposed to represent their economic value.

The previous Reports included the principal Welsh and Newcastle coals, and introduced the consideration of the varieties raised in Lancashire. In the present Report we continue the examination of such specimens of Welsh and Newcastle coals as appeared to be desirable to complete the information on the characters of the coals of these districts, and the examination of the coals of Lancashire is much extended. The coals of the Derbyshire district, so far as they have been sent to us, have also been subjected to experiment. The coals of Scotland have not been furnished in the number desirable to determine the relative values of the different coal-fields of that country. In accordance with our instructions, we have only examined those which were actually sent for the purpose of examination, and have not felt authorised to make purchases to complete the series.

A number of coals from foreign countries and from the Colonies, which have been from time to time transmitted by the Admiralty, have been analysed and generally examined. The quantities of these were insufficient for experiments under the boiler.

The requirements of the Naval service in respect to fuel are so various, that it has been considered expedient to examine the coals by districts, in order that the superior merits of the coals of each district might be properly elicited. It is rare to find one coal in which is combined all the qualities essential for the requirements of a ship of war, viz. a quick production of steam—large evaporative powers—a smokeless combustion—a capacity for stowage in small bulk—the power of resisting attrition—a freedom from the qualities which tend to spontaneous combustion, in addition to other properties of less importance. The combination, so far as it extends, and the peculiar merits of each coal, are registered in the individual examinations, but cannot be reduced into a tabular form.

The Appendix to this Report gives a description in detail of the experiments made subsequent to that which we had the honour to lay before your Lordship's predecessor. It would, however, appear expedient in this the last Report to sum up in a tabular form the general results of the inquiry.

In Table I. the economic values of thirty-seven Welsh coals are described. The variety of the coals of this field led to the expectation that their examination might yield results by which a combination of the desired conditions might be obtained. It is well known that the composition of the Welsh coals varies from that kind commonly termed bituminous to the anthracite. In general properties, also, this field produces coals of the character known as free-burning, in addition to those anthracites which require peculiar adaptations before being burned economically in ordinary furnaces.

TABLE I.—Showing the Economic Values of the Welsh Coals.

Names of Coals employed in the Experiments.	Economic evaporating power, or pounds of water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for Fuel. — lbs.	Weight of 1 cubic foot as calculated from the density. — lbs.	Ratio of B. to C. or of the economical to the theoretical weight.	Difference per cent. between theoretical and economical weight.	Space occupied by 1 ton in cubic feet (economic weight).	Results of experiments on cohesive power of Coals (per centage of large Coals).	Evaporating power of Coal, after deducting for combustible matter in residue.	Weight of water evaporated from 212° by 1 cubic foot of Coal. — lbs.	Rate of Evaporation, or number of pounds of water evaporated per hour. — Mean.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.
Aberaman Merthyr. . .	10·75	48·9	81·91	·597	67·50	45·80	..	..	525·67	..
Ebbw Vale	10·21	53·3	78·81	·676	45·98	42·26	45·0	10·64	544·19	460·22
Thomas's Merthyr . . .	10·16	53·0	82·29	·644	55·26	42·26	57·5	10·72	538·48	520·8
Duffryn	10·14	53·22	82·72	·643	55·43	42·09	56·2	11·80	540·12	409·32
Nixon's Merthyr . . .	9·96	51·7	82·29	·628	59·16	43·32	64·5	10·70	514·93	511·4
Binea	9.94	57·08	81·357	·702	42·53	39·24	51·2	10·3	587·92	486·95
Bedwas	9·79	50·5	82·6	·611	63·565	44·32	54·0	9·99	494·39	476·96
Hill's Plymouth Work . .	9·75	51·2	84·78	·603	65·68	43·74	64·0	10·18	499·20	531·6
Aberdare Compy.'s Merthyr	9·73	49·3	81·73	·603	65·78	45·43	74·5	10·27	479·68	489·5
Gadly Nine-feet Seam . .	9·56	54·8	83·16	·658	51·75	40·87	76·0	10·46	523·88	517·3
Resolven	9·53	58·66	82·354	·712	40·39	38·19	35·0	10·44	559·02	390·25
Mynydd Newydd . . .	9·52	56·33	81·73	·689	45·09	39·76	53·7	10·59	536·26	470·69
Abercarn	9·47	50·3	83·22	·604	65·44	44·53	54·5	9·63	443·96	480·00
Anthracite, Jones and Co. .	9·46	58·25	85·786	·679	47·26	38·45	68·5	9·7	565·02	409·37
Ward's Fiery Vein . . .	9·40	57·433	83·85	·685	46·00	39·00	46·5	10·6	608·78	529·90
Neath Abbey	9·38	59·3	83·57	·709	40·92	37·77	50·0	9·65	556·23	546·1
Graigola.	9·35	60·166	81·107	·742	34·8	37·23	49·3	9·66	581·20	441·48
Gadly Four-feet Seam . .	9·29	51·6	82·79	·623	60·44	43·41	68·5	10·73	479·36	400·0
Machen Rock Vein . .	9·23	48·1	80·91	·594	68·21	46·56	52·5	9·43	443·96	488·75
Birch Grove, Graigola . .	9·22	51·0	84·85	·601	66·37	43·92	59·0	9·64	470·22	507·50
Llynvi	9·19	53·3	80·35	·663	50·56	42·02	..	9·58	429·82	399·50
Cadoxton	8·97	58·1	85·97	·675	47·96	38·55	..	9·07	521·15	344·16
Oldcastle Fiery Vein . .	8·94	50·916	80·42	·633	57·946	43·99	57·7	..	455·18	464·30
Vivian and Sons' . . .	8·92	47·9	81·04	·591	69·18	46·76	54·0	9·11	427·26	421·25
Llangennech	8·86	56·93	81·85	·695	43·76	39·34	53·5	9·2	523·75	373·22
Three-quarter Rock Vein .	8·84	56·388	83·60	·674	48·26	39·72	52·7	..	498·46	486·86
Pentrepoth	8·72	57·72	81·73	·705	40·17	38·80	46·5	8·98	518·32	381·50
Cwm Frood Rock Vein .	8·70	55·277	78·299	·706	41·648	40·52	72·5	9·38	480·90	379·80
Cwm Nanty Gros . . .	8·42	56·0	79·859	·701	42·60	40·00	55·7	8·82	471·52	404·16
Brymbo Main	8·36	47·0	81·10	·579	72·55	47·65	..	8·56	392·92	435·83
Vivian and Sons' Rock Vawr	8·08	48·9	81·16	·602	65·97	45·80	70·5	8·19	395·11	492·50
Coleshill	8·0	53·0	80·483	·658	51·85	42·26	62·0	8·34	424·0	406·41
Brymbo Two-yard . . .	7·85	47·9	80·04	·598	67·11	46·76	79·5	7·91	376·00	441·66
Rock Vawr	7·68	55·0	80·21	·685	45·83	40·72	65·5	7·88	422·40	397·5
Porth-mawr	7·53	53·3	86·722	·614	62·7	42·02	62·0	7·75	401·34	347·44
Pontypool	7·47	55·7	83·35	·676	47·845	40·216	57·5	8·04	416·07	250·40
Pentrefelin	6·36	66·166	84·726	·781	28·051	33·85	52·7	7·4	489·62	247·24

Each of these coals has been analysed, with a view to the identification of specimens of average quality. Although the analyses show generally that the quantities of carbon and hydrogen regulate materially the economic values of the coals, still there are marked exceptions to this rule, showing that the inquiry would have been far from sufficient had we not elicited the economic values of the coals by actual trial under the boilers.

TABLE II.—Showing the Mean Composition of Average Samples of the Welsh Coals.

Locality or Name of Coal.	Specific gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
	A.	B.	C.	D.	E.	F.	G.	H.
Aberaman Merthyr. . .	1·305	90·94	4·28	1·21	1·18	0·94	1·45	85·0
Ebbw Vale	1·275	89·78	5·15	2·16	1·02	0·39	1·50	77·5
Thomas's Merthyr . . .	1·30	90·12	4·33	1·00	0·85	2·02	1·68	86·53
Duffryn	1·326	88·26	4·66	1·45	1·77	0·60	3·26	84·3
Nixon's Merthyr . . .	1·31	90·27	4·12	0·63	1·20	2·53	1·25	79·11
Binea	1·304	88·66	4·63	1·43	0·33	1·03	3·96	88·10
Bedwas	1·32	80·61	6·01	1·44	3·50	1·50	6·94	71·7
Hill's Plymouth Work. .	1·35	88·49	4·00	0·46	0·84	3·82	2·39	82·25
Aberdare Co.'s Merthyr .	1·31	88·28	4·24	1·66	0·91	1·65	3·26	85·83
Gadly Nine-feet Seam . .	1·33	86·18	4·31	1·09	0·87	2·21	5·34	86·54
Resolven.	1·32	79·33	4·75	1·38	5·07	Included in Ash.	9·41	83·9
Mynydd Newydd . . .	1·31	84·71	5·76	1·56	1·21	3·52	3·24	74·8
Abercarn	1·334	81·26	6·31	·77	1·86	9·76	2·04	68·4
Anthracite, Jones and Co. .	1·375	91·44	3·46	0·21	0·79	2·58	1·52	92·9
Ward's Fiery Vein . . .	1·344	87·87	3·93	2·02	0·83	Included in Ash.	7·04	. .
Neath Abbey	1·31	89·04	5·05	1·07	1·60	. .	3·55	61·42
Graigola.	1·30	84·87	3·84	0·41	0·45	7·19	3·24	85·5
Gadly Four-feet Seam . .	1·32	88·56	4·79	0·88	1·21	. .	4·88	88·23
Machen Rock Vein . . .	1·297	71·08	4·88	·95	1·37	17·87	3·85	65·2
Birch Grove, Graigola . .	1·360	84·25	4·15	·73	·86	5·58	4·43	85·1
Llynvi	1·28	87·18	5·06	0·86	1·33	2·53	3·04	72·94
Cadoxton	1·378	87·71	4·34	1·05	1·75	1·58	3·57	82·0
Oldcastle Fiery Vein . .	1·289	87·68	4·89	1·31	0·09	3·39	2·64	79·8
Vivian and Sons' Merthyr .	1·299	82·75	5·31	1·04	·95	4·64	5·31	67·1
Llangennech	1·312	85·46	4·20	1·07	0·29	2·44	6·54	83·69
Three-quarter Rock Vein .	1·34	75·15	4·93	1·07	2·85	5·04	10·96	62·5
Pentrepoth	1·31	88·72	4·50	0·18	. .	3·24	3·36	82·5
Cwm Frood Rock Vein .	1·255	82·25	5·84	1·11	1·22	3·58	6·00	68·8
Cwm Nanty Gros . . .	1·28	78·36	5·59	1·86	3·01	5·58	5·60	65·6
Brymbo Main	1·300	77·87	5·09	·57	2·73	9·52	4·22	55·4
Vivian & Sons' Rock Vawr	1·301	79·09	5·20	·66	2·41	8·34	4·30	58·6
Coleshill	1·29	73·84	5·14	1·47	2·34	8·29	8·92	56·0
Brymbo Two-yard . . .	1·283	78·13	5·53	·54	1·88	8·02	5·90	56·2
Rock Vawr	1·29	77·98	4·39	0·57	0·96	8·55	7·55	62·50
Porth-mawr	1·39	74·70	4·79	1·28	0·91	3·60	14·72	63·1
Pontypool	1·32	80·70	5·66	1·35	2·39	4·38	5·52	64·8
Pentrefelin	1·358	85·52	3·72	Trace.	0·12	4·55	6·09	85·0

The excellent varieties of coal in the Newcastle coal-field, and the facility offered by that district for their shipment and ready transport, rendered it important that these coals should be examined in detail. Accordingly the fact of the progress of the inquiry was made known in that district by a personal visit, and the coal-owners were requested to furnish their varieties of coal for examination. Specimens were sent in consequence of this request, and the following Table (Table III.) exhibits the economic values of nineteen of the principal varieties :—

TABLE III.—Showing the Economic Values of the Newcastle Coals.

mes of Coals employed in Experiments.	Economic evaporating power, or number of lbs. of Water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for Fuel. — lbs.	Weight of 1 cubic foot as calculated from the Density. — lbs.	Ratio of B. to C., or of the economical to the theoretical Weight.	Difference per cent. between theoretical and economical Weights.	Space occupied by 1 ton in cubic feet (economic Weight).	Results of experiments on cohesive power of Coal (percentage of large Coals).	Evaporating power of the Coal after deducting for combustible matter in residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal.	Rate of evaporation, or number of lbs. of Water evaporated per hour. — Mean.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.
ington	9·95	53·2	79·87	·666	50·13	42·10	43·00	10·16	529·34	. .
ews House Tanfield	9·39	52·1	78·86	·660	51·36	42·99	. .	9·80	489·21	351·2
den Close	9·38	50·6	79·87	·633	57·84	44·26	38·5	9·67	474·62	. .
rell Wallsend . .	8·87	47·4	80·23	·590	69·26	47·25	73·0	9·07	420·43	411·66
castle Hartley . .	8·23	50·5	80·27	·629	58·95	44·35	78·5	8·65	415·61	308·0
ey's Hartley . . .	8·16	52·0	81·79	·635	57·28	43·07	85·5	8·71	424·32	300·8
' West Hartley . .	8·04	50·8	78·17	·649	53·89	44·13	69·5	8·26	408·43	406·8
Hartley Main . .	7·87	48·9	78·86	·620	61·26	45·80	79·0	8·05	384·84	457·50
lle's West Hartley .	7·82	50·6	77·11	·656	52·39	44·09	80·0	8·01	395·69	413·3
ings' Hartley . . .	7·77	48·5	78·04	·621	60·90	46·18	75·5	7·96	376·84	404·5
s Hartley	7·71	47·8	78·23	·611	63·66	46·86	77·5	8·13	368·53	344·3
son's West Hartley .	7·61	47·7	78·36	·608	64·27	46·96	76·5	7·83	362·99	402·9
h Percy Hartley . .	7·57	49·1	78·29	·627	59·45	45·62	60·0	7·72	371·68	423·5
rell Coal Co.'s Steam- at Wallsend.	7·48	49·5	79·36	·623	60·32	45·25	79·5	7·85	370·66	291·8
rentwater Hartley .	7·42	50·4	78·79	·639	56·32	44·44	63·5	7·66	373·96	451·1
mhill	7·3	52·5	77·988	·673	48·55	42·67	65·7	7·66	383·25	397·78
nal Hartley . . .	6·82	49·1	77·98	·629	58·81	45·62	80·0	6·98	334·86	428·4
en & Sidney's Hartley	6·79	47·9	78·67	·608	64·23	46·76	74·0	7·02	325·24	350·4

The coals of the Newcastle district are in general of very different composition from the Welsh coals. They are characterised by containing a smaller quantity of carbon, but a larger amount of hydrogen. This latter element exercises in this case a very essential importance in their heating powers, and must not be neglected in comparing the analytical with the economic results. As a general rule, subject, however, as in the previous case, to marked exceptions, the practical value of the coals rises with the increase in these two combustible elements. Nevertheless, the mechanical conditions of a coal very frequently modify the practical result to an extent which was scarcely to be expected. The physical condition of a coal, according as it facilitates or opposes the entrance of air for combustion, produces a most marked influence in its evaporative powers, and often determines the practical results obtained from it more than the composition of the coal itself. It is, therefore, not a safe guide to rely wholly on the analysis of a coal, unless at the same time practical experiments are found to coincide with the approximative value indicated by analysis.

TABLE IV.—Showing the Mean Composition of Average Samples of the Newcastle Coals.

Locality or Name of Coal.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
	A.	B.	C.	D.	E.	F.	G.	H.
Willington	..	86·81	4·96	1·05	0·88	5·22	1·08	72·19
Andrews House, Tanfield	1·26	85·58	5·31	1·26	1·32	4·39	2·14	65·13
Bowden Close	..	84·92	4·53	0·96	0·65	6·66	2·28	69·69
Haswell Wallsend . . .	1·286	83·47	6·68	1·42	·06	8·17	0·20	62·70
Newcastle Hartley . . .	1.29	81·81	5·50	1·28	1·69	2·58	7·14	64·61
Hedley's Hartley . . .	1·31	80·26	5·28	1·16	1·78	2·40	9·12	72·31
Bates' West Hartley . .	1·25	80·61	5·26	1·52	1·85	6·51	4·25	..
West Hartley Main . .	1·264	81·85	5·29	1·69	1·13	7·53	2·51	59·20
Buddle's West Hartley .	1·23	80·75	5·04	1·46	1·04	7·86	3·85	..
Hastings' Hartley . . .	1·25	82·24	5·42	1·61	1·35	6·44	2·94	35·60
Carr's Hartley	1·25	79·83	5·11	1·17	0·82	7·66	5·21	60·63
Davison's West Hartley .	1·25	83·26	5·31	1·72	1·38	2·50	5·84	59·49
North Percy Hartley . .	1·25	80·03	5·08	0·98	0·78	9·91	3·22	57·18
Haswell Coal Co.'s Steam-boat Wallsend.	1·27	83·71	5·30	1·06	1·21	2·79	5·93	61·38
Derwentwater Hartley .	1·26	78·01	4·74	1·84	1·37	10·31	3·73	54·83
Broomhill	1·25	81·70	6·17	1·84	2·85	4·37	3·07	59·20
Original Hartley . . .	1·25	81·18	5·56	0·72	1·44	8·03	3·07	58·22
Cowpen & Sidney's Hartley	1·26	82·20	5·10	1·69	0·71	7·97	2·33	58·59

The coals of Derbyshire are now brought up to London by railway, and consumed to a considerable extent in the metropolis. It was therefore desirable to examine their general character, by testing the few specimens of steam-coals which were offered for that purpose.

TABLE V.—Showing the Economic Value of certain Derbyshire Coals.

Names of Coals employed in Experiments.	Economic evaporating power, or number of lbs. of Water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for Fuel. lbs.	Weight of 1 cubic foot as calculated from the Density. lbs.	Ratio of B. to C., or of the economical to the theoretical Weight.	Difference per cent. between theoretical and economical Weights.	Space occupied by 1 ton in cubic feet (economic Weight).	Results of experiments on cohesive power of Coals (percentage of large Coals).	Evaporating power of the Coal after deducting for combustible matter in residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal.	
	A.	B.	C.	D.	E.	F.	G.	H.	I.	
Earl Fitzwilliam's Elsecar	8·52	47·2	80·85	·583	70·29	47·45	77·0	8·78	402·14	4
Hoyland & Co.'s Elsecar .	8·07	48·2	82·16	·586	70·45	46·47	82·5	8·43	388·97	3
Earl Fitzwilliam's Park Gate.	7·92	47·0	81·79	·574	74·02	47·65	78·0	8·24	372·24	3
Butterly Co.'s Portland .	7·92	47·1	81·16	·580	72·31	47·55	89·0	8·04	373·03	4
Butterly Co.'s Langley .	7·80	47·8	78·86	·606	64·97	46·86	84·5	7·98	372·84	3
Stavely	7·26	49·9	79·79	·625	59·90	44·88	88·5	7·40	362·27	4
Loscoe Soft	6·88	44·8	80·17	·558	78·95	50·00	62·0	6·99	308·22	4
Loscoe Hard	6·32	45·9	79·60	·576	73·42	48·80	86·0	..	290·08	4

The composition of Derbyshire coals is in many respects similar to those from Newcastle, but in general they appear to contain rather a smaller quantity of carbon. The values of the coals of this district, as far as regards their evaporative powers, have not yet been determined on many varieties. It would, however, appear that their values, as ascertained by direct experiment under the boiler and by analysis, nearly coincide.

TABLE VI.—Showing the Mean Composition of Average Samples of certain Derbyshire Coals.

Locality or Name of Coal.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
	A.	B.	C.	D.	E.	F.	G.	H.
Earl Fitzwilliam's Elsecar	1·296	81·98	4·85	1·27	·91	8·58	2·46	61·6
Hoyland & Co.'s Elsecar .	1·317	80·05	4·93	1·24	1·06	8·99	3·73	62·5
Earl Fitzwilliam's Park Gate.	1·311	80·07	4.92	2·15	1·11	9·95	1·80	61·7
Butterly Co.'s Portland .	1·301	80·41	4·65	1·59	·86	11·26	1·23	60·9
Butterly Co.'s Langley .	1·264	77·97	5·58	·80	1·14	9·86	4·65	54·9
Stavely	1·27	79·85	4·84	1·23	0·72	10·96	2·40	57·86
Loscoe Soft	1·285	77·49	4·86	1·64	1·30	12·41	2·30	52·8

The Lancashire coals, from their vicinity to shipping ports and their increasing use for Naval purposes, became an important subject of inquiry. Numerous varieties from this coal-field have been examined, and their economic values determined. The peculiar characteristics of this variety of coal are noticed under the special descriptions attached to each specimen examined. The general results are contained in the following table:—

TABLE VII.—Showing the Economic Values of the Lancashire Coals.

Coals employed in Experiments.	Economic evaporating power, or number of lbs. of Water evaporated from 212 by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for Fuel. — lbs.	Weight of 1 cubic foot of Coal as calculated from the Density. — lbs.	Ratio of B to C, or of the economical to the theoretical Weight.	Difference per cent. between theoretical and economical Weight.	Space occupied by 1 ton in cubic feet (economic Weight).	Results of experiments on cohesive power of Coals (percentage of large Coals).	Evaporating power of the Coal after deducting for combustible matter in the residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal.	Rate of evaporation, or number of lbs. of Water evaporated per hour. — Mean.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.
l Co.'s Arley . .	9·47	47·6	79·36	·599	66·72	47·05	73·5	9·35	435·06	487·29
Little Delf . .	9·13	44·9	78·42	·572	74·65	49·88	66·5	9·26	409·93	532·91
Arley . . .	8·83	50·5	78·17	·646	54·79	44·35	76·0	9·09	445·91	454·1
Hurst. . . .	8·81	48·0	78·90	·608	64·37	46·66	65·0	9·00	422·88	500·8
) Pemberton Yard	8·78	48·0	84·10	.570	75·20	46·66	75·5	. .	421·44	461·25
Rushy Park . .	8·74	49·3	82·54	·597	67·42	45·43	77·0	8·91	430·88	461·66
ll Pemberton Four-	8·52	47·3	78·48	·602	65·91	47·35	71·5	8·65	402·99	480·00
Higher Florida .	8·39	49·5	75·99	·651	53·51	45·25	74·0	8·49	415·30	467·50
l Pemberton Four-	8·34	51·8	79·60	·650	53·66	43·24	74·5	8·45	432·01	497·39
ok Little Delf. .	8·29	51·0	78·16	·652	53·25	43·92	61·5	8·55	422·79	440·4
. . . . .	8·17	50·8	81·10	·626	59·64	44·09	78·5	8·35	415·03	395·41
rk Mine . . .	8·08	47·0	80·04	·587	70·31	47·65	67·0	8·35	379·76	419·1
ok Rushy Park .	8·02	55·3	80·15	·689	44·93	40·50	80·5	8·26	443·50	481·2
and Wirthington's Park.	8·01	50·0	80·10	·624	60·20	44·80	69·0	8·16	400·50	454·5
ushy Park . .	7·98	52·6	84·07	·625	59·82	42·58	75·5	8·16	419·74	435·0
Haigh Yard . .	7·90	50·8	80·10	·634	57·67	44·13	80·0	8·23	401·32	398·3
Florida Main .	7·83	48·0	79·04	·507	64·66	46·66	81·5	7·97	375·84	422·50
our-Feet . . .	7·77	53·4	75·49	·707	41·36	41·94	75·0	8·05	414·91	414·79
l Pemberton Five-	7·72	51·8	79·17	·654	52·83	43·24	71·5	7·95	399·89	495·20
Wigan) . . .	7·70	48·3	76·80	·628	59·00	46·37	95·0	8·06	371·91	381·1
l Co.'s Furnace Vein	7·47	49·3	81·98	·601	66·28	45·43	71·5	7·84	368·27	435·21
Lindsay . . .	7·44	51·1	78·61	·650	53·83	45·83	70·0	7·58	380·18	431·5
and Thompson's Park.	7·34	47·5	79·29	·599	66·92	47·15	76·0	7·43	348·65	449·79
Five-Feet . .	7·21	49·0	79·11	·619	61·44	45·71	44·5	7·35	353·29	489·5
ll Pemberton Five-	7·13	48·3	80·04	·603	65·71	46·37	78·5	7·29	344·37	417·18
ll Co.'s New Mine	7·04	48·4	79·73	·607	64·73	46·28	76·5	7·16	340·73	422·08
and Thompson's Delf.	6·85	48·4	79·48	·608	64·21	46·28	77·0	6·94	331·54	484·28
and Wirthington's m.	6·32	51·6	81·73	·631	58·39	43·41	82·0	6·62	326·11	362·7

The composition of the Lancashire coals has also been determined; but in them, as in the other cases alluded to, the same exceptional differences, due to the variations in their mechanical conditions, are observed, although generally the analytical value corresponds with that obtained by the boiler experiments.

TABLE VIII.—Showing the Mean Composition of Average Samples of the Lancashire Coals.

Locality or Name of Coal.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
	A.	B.	C.	D.	E.	F.	G.	H.
Ince Hall Co.'s Arley	1·272	82·61	5·86	1·76	·80	7·44	1·53	64·0
Haydock Little Delf	1·257	79·71	5·16	·54	·52	10·65	3·42	58·1
Balcarres Arley	1·26	83·54	5·24	·98	1·05	5·87	3·32	62·89
Blackley Hurst	1·26	82·01	5·55	1·68	1·43	5·28	4·05	57·84
Ince Hall Pemberton Yard	1·348	80·78	6·23	1·30	1·82	7·53	2·34	60·6
Haydock Rushy Park	1·323	77·65	5·53	·50	1·73	10·91	3·68	59·4
Moss Hall Pemberton Four-feet	1·258	75·53	4·82	2·05	3·04	7·98	6·58	55·7
Haydock Higher Florida	1·218	77·33	5·56	1·01	1·03	12·02	3·05	51·1
Ince Hall Pemberton Four-feet	1·276	77·01	3·93	1·40	1·05	5·52	1·09	57·1
Blackbrook Little Delf	1·26	82·70	5·55	1·48	1·07	4·89	4·31	58·48
King	1·300	73·66	5·30	1·68	1·58	9·06	8·72	62·4
Rushy Park Mine	1·28	77·76	5·23	1·32	1·01	8·99	5·69	56·66
Blackbrook Rushy Park	1·27	81·16	5·99	1·35	1·62	7·20	2·68	58·10
Johnson and Wirthington's Rushy Park.	1·28	79·50	5·15	1·21	2·71	9·24	2·19	57·52
Laffak Rushy Park	1·35	80·47	5·72	1·27	1·39	8·33	2·82	56·26
Balcarres Haigh Yard	1·28	82·26	5·47	1·25	1·48	5·64	3·90	66·09
Haydock Florida Main	1·267	77·49	5·50	1·27	·88	12·84	2·02	54·4
Wigan Four-feet	1·209	78·86	5·29	·86	1·19	9·57	4·23	60·0
Ince Hall Pemberton Five-feet	1·269	68·72	4·76	2·20	1·35	18·63	14·34	56·5
Cannel (Wigan)	1·23	79·23	6·08	1·18	1·43	7·24	4·84	60·33
Ince Hall Co.'s Furnace Vein	1·314	74·74	5·71	1·53	·96	13·52	4·04	58·4
Balcarres Lindsay	1·26	83·90	5·66	1·40	1·51	5·53	2·00	57·84
Caldwell and Thompson's Rushy Park.	1·271	76·17	5·46	1·09	·91	14·87	1·50	58·7
Balcarres Five-feet	1·26	74·21	5·03	·77	2·09	8·69	9·21	55·90
Moss Hall Pemberton Five-feet	1·283	76·16	5·35	1·29	1·05	10·13	6·02	56·1
Moss Hall Co.'s New Mine	1·278	77·50	4·84	·98	1·36	12·16	3·16	57·7
Caldwell and Thompson's Higher Delf.	1·274	75·40	4·83	1·41	2·43	19·98	5·95	54·2
Johnson and Wirthington's Sir John.	1·31	72·86	4·98	1·07	1·54	8·15	11·40	56·15

In addition to the coals of the districts to which we have made special reference, other localities have furnished coals, although not in sufficient numbers to entitle any general conclusions to be drawn from these observations. Among these the most interesting is the Scotch coal-field, which is worthy of careful examination from the importance of the coals found in it, and from their recognised value as steam-producing coals; but from the causes which we have already mentioned, these coals have not been furnished to us in sufficient number.

Various coals from other localities, and those artificial mixtures known as patent-fuels, have also been examined, and are described in the following Table:—

TABLE IX.—Showing the Economic Values of various Coals.

	Names of Coals employed in the Experiments.	Economic evaporating power, or number of lbs. of Water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for fuel. — lbs.	Weight of 1 cubic foot of Coal as calculated from the Density. — lbs.	Ratio of B to C, or of the economical to the theoretical Weight.	Difference per cent. between theoretical and economical Weight.	Space occupied by 1 ton in cubic feet (economic Weight).	Results of experiments on cohesive power of Coals (percentage of large Coals).	Evaporating power of the Coal, after deducting for the combustible matter in the residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal.
		A.	B.	C.	D.	E.	F.	G.	H.	I.
Scotch Coals.	Wallsend Elgin	8·46	54·6	78·611	·694	43·78	41·02	64·0	8·67	460·82
	Wellewood	8·24	52·6	79·78	·659	53·57	42·58	80·0	8·39	433·42
	Dalkeith Coronation Seam	7·71	51·66	78·611	·657	52·17	43·36	88·2	7·86	398·29
	Kilmarnock Skerrington	7·66	44·7	77·42	·577	73·19	50·11	63·5	7·82	342·40
	Fordel Splint	7·56	55·0	78·611	·699	42·92	40·72	63·0	7·69	415·80
	Grangemouth	7·40	54·25	80·48	·674	48·35	40·13	69·7	7·91	401·45
	Eglinton	7·37	52·0	79·84	·651	51·48	43·07	79·5	7·48	383·24
	Dalkeith Jewel Seam	7·08	49·8	79·672	·625	59·984	44·98	85·7	7·10	352·58
	Slievardagh Irish Anthracite	9·85	62·8	99·57	·630	58·55	35·66	74·0	10.49	618·58
Various.	Coleshill Co.'s Bagilt Main	8·33	49·6	79·17	·626	59.61	45·16	79·0	8·50	413·16
	Ewloe	7·02	50·4	79·54	·633	57·81	44·44	84·0	7·16	353·80
	Ibstock	6·91	47·3	80·54	·587	70·27	47·35	62·0	7·02	326·84
	Lydney (Forest of Dean)	8·52	54·44	80·046	·68	47·02	41·14	55·0	8·98	463·86
	Conception Bay, Chili	5·72	..	80·54	..	..	..	..	5·96	..
Patent Coals.	Warlich's Patent Fuel	10·36	69·05	72·248	·955	4·49	32·44	..	10·60	715·35
	Livingstone's Steam Fuel	10·03	65·6	73·86	·888	12·59	34·14	..	10·57	657·96
	Lyon's Patent Fuel	9·58	61·1	74·73	·817	22·30	36·66	..	9·77	585·33
	Wylam's	8·92	65·08	68·629	·948	5·45	34·41	..	9·74	580·51
	Bell's	8·53	65·3	71·124	·918	8·91	34·30	..	8·65	557·0
	Holland and Green's	7·59	64·8	81·23	·797	25·35	34·56	..	7·86	491·83

The composition of these coals has also been determined, and is shown in Table X.

TABLE X.—Showing the Mean Composition of Average Samples of various Coals.

	Locality or Name of Coal.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
		A.	B.	C.	D.	E.	F.	G.	H.
Scotch Coals.	Wallsend Elgin	1·20	76·09	5·22	1·41	1·53	5·05	10·70	58·45
	Wellewood	1·27	81·36	6·28	1·53	1·57	6·37	2·89	59·15
	Dalkeith Coronation Seam	1·316	76·94	5·20	Trace.	0·38	14·37	3·10	53·5
	Kilmarnock Skerrington	1·241	79·82	5·82	·94	·86	11·31	1·25	49·3
	Fordel Splint	1·23	79·58	5·50	1·13	1·46	8·33	4·00	52·03
	Grangemouth	1·29	79·85	5·28	1·35	1·42	8·58	3·52	56·6
	Eglinton	1·25	80·08	6·50	1·55	1·38	8·05	2·44	54·94
	Dalkeith Jewel Seam	1·277	74·55	5·14	0·10	0·33	15·51	4·37	49·8
	Slievardagh Irish Anthracite	1·59	80·03	2·30	0·23	6·76	Included in Ash.	10·80	90·1
Various.	Coleshill Co.'s Bagilt Main	1·269	88·48	5·62	2·02	1·36	0·86	1·62	55·8
	Ewloe	1·275	80·97	4·96	1·10	1·40	8·20	3·37	54·5
	Ibstock	1·291	74·97	4·83	·88	1·45	11·88	5·99	50·8
Patent Coals.	Warlich's Patent Fuel	1·15	90·02	5·56	Trace.	1·62	Included in Ash.	2·91	85·1
	Livingstone's Steam Fuel	1·184	86·07	4·13	1·80	1·45	2·03	4·52	..
	Lyon's Patent Fuel	1·13	86·36	4·56	1·06	1·29	2·07	4·66	..
	Wylam's	1·10	79·91	5·69	1·68	1·25	6·63	4·84	65·8
	Bell's	1·14	87·88	5·22	0·81	0·71	0·42	4·96	71·7
	Holland and Green's	1·302	70·14	4·65	1·15	..	..	13·73	..

It may be useful in this Report to give, as the general results of the examination of different coals, the averages of the coals examined from each district. Although the averages are deduced from an unequal number of observations, still these are in most cases sufficiently large to give an approximative average of value.

TABLE XI.—Showing the Average Value of Coals from different Localities.

Locality.	Evaporating power, or number of lbs. of Water evaporated from 212° by 1 lb. of Coal.	Rate of evaporation, or number of lbs. evaporated per hour.	Weight in lbs. of 1 cubic foot of Coal as used for Fuel.	Space occupied by 1 ton in cubic feet.	Results obtained in experiments on cohesive power of Coals (percentage of large Coals).	Percentage amount of Sulphur contained in Coals.
	A.	B.	C.	D.	E.	F.
Average of 37 samples from Wales	9·05	448·2	53·1	42·71	60·9	1·42
,, 17 ,, Newcastle	8·37	411·1	49·8	45·3	67·5	0·94
,, 28 ,, Lancashire	7·94	447·6	49·7	45·15	73·5	1·42
,, 8 ,, Scotland	7·70	431·4	50·0	49·99	73·4	1·45
,, 8 ,, Derbyshire	7·58	432·7	47·2	47·45	80·9	1·01

It is interesting to know the average composition of the coals of the various districts, on nearly the same number of observations; although, from the reasons formerly stated, this is not always coincident with the economic value.

TABLE XII.—Showing the Average Composition of Coals from different Localities.

LOCALITY.	Specific Gravity of Coal.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Percentage of Coke left by each Coal.
	A.	B.	C.	D.	E.	F.	G.	H.
Average of 36 samples from Wales . .	1·315	83·78	4·79	0·98	1·43	4·15	4·91	72·60
,, 18 ,, Newcastle .	1·256	82·12	5·31	1·35	1·24	5·69	3·77	60·67
,, 28 ,, Lancashire .	1·273	77·90	5·32	1·30	1·44	9·53	4·88	60·22
,, 8 ,, Scotland . .	1·259	78·53	5·61	1·00	1·11	9·69	4·03	54·22
,, 7 ,, Derbyshire .	1·292	79·68	4·94	1·41	1·01	10·28	2·65	59·32

The foreign coals examined are of interest, from the very different sources from which they have been sent. Although in general inferior in composition to those of the United Kingdom, still a knowledge of their general characters is important as a possible means of furnishing a supply of fuel to vessels at a distance from depôts of coal, and as a means of drawing attention to undeveloped resources of industry.

TABLE XIII.—Showing the Mean Composition of Average Samples of Foreign Coals.

	LOCALITY.	Specific Gravity of Coal.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.
		A.	B.	C.	D.	E.	F.	G.
Van Dieman's Land Coals.	South Cape	..	63·40	2·89	1.27	0·98	1·01	30·45
	Mount Nicholas Break o'Day	..	57·37	3·91	1·15	0·90	9·10	27·55
	Tingal	..	57·21	3·38	1·20	1·32	7·80	29·09
	Jerusalem	..	68·18	3·99	1·62	1·12	5·89	19·20
	Douglas River, East Coast .	..	70·44	4·20	1·11	0·70	9·27	14·28
	Tasman's Peninsula . . .	..	65·54	3·36	1·91	1·03	1·75	26·41
	Schonten Island	..	64·01	3·55	0·94	0·85	3·38	27·17
	Whale's Head, South Cape .	..	65·86	3·18	1·12	1·14	7·20	21·50
	Adventure Bay	..	80·22	3·05	1·36	1·90	4·80	8·67
Sydney, New South Wales . .		..	82·39	5·32	1·23	0·70	8·32	2·04
	Borneo (Labuan Kind) . .	1·28	64·52	4·74	0·80	1·45	20·75	7·74
	,, Three-feet Seam . .	1·37	54·31	5·03	0·98	1·14	24·22	14·32
	,, Eleven-feet Seam . .	1·21	70·33	5·41	0·67	1·17	19·19	3·23
Formosa Island.		1·24	78·26	5·70	0·64	0·49	10·95	3·96
Vancouver's.		..	66·93	5·32	1·02	2·20	8·70	15·83
Lignite, Trinidad		..	65·20	4·25	1·33	0·69	21·69	6·84
Chili Coals.	Conception Bay	1·29	70·55	5·76	0·95	1·98	13·24	7·52
	Port Famine	..	64·18	5·33	0·50	1·03	22·75	6·21
	Chirique	..	38·98	4·01	0·58	6·14	13·38	36·91
	Laredo Bay	..	58·67	5·52	0·71	1·14	17·33	16·63
	Talcahnano Bay	..	70·71	6·44	1·08	0·94	13·95	6·92
	Colcurra Bay	..	78·30	5·50	1·09	1·06	8·37	5·68
Patagonia Coals.	Sandy Bay No. 1	..	62·25	5·05	0·63	1·13	17·54	13·40
	,, ,, No. 2	..	59·63	5·68	0·64	0·96	17·45	15·64

In concluding this Report, we have again to express our gratification at the cordial support which we have always met with from coal-owners and from others interested in the investigation. But for this ready co-operation the inquiry could not have been prosecuted except under circumstances of much difficulty and cost. Our own services have, as hitherto, been freely given to the inquiry; but our labours have been much lessened by the willing aid which we have everywhere experienced.

We have the honour to be, &c.,

H. T. DE LA BECHE.

LYON PLAYFAIR.

APPENDIX.

ADMIRALTY COALS INVESTIGATION.

On the Evaporative Powers of Coals, &c., by J. Arthur Phillips.

The following experiments have been conducted in all respects similarly to those described in the "Second Report on the Coals suited to the Steam Navy;" the water being evaporated at atmospheric pressure, and the results calculated by the formulæ there given.*

* The principal formulæ employed in these calculations are as follows:—

For the determination of the evaporative power of the coals, we have

$$\frac{(W - Eq + w - w')\,l + (W + w - w')\,t + wt' + (w' -)\,t''}{Pl} = E'$$

in which W is the weight of water let down from the tanks during the experiment.

E = the coefficient of evaporative power of wood.
q = the weight of wood used for lighting the fire.
w = the weight of water (as found by the Table of Expansion) contained in the boiler at commencement of experiment.
w' = the weight of water in boiler at close of experiment.
l = the coefficient of the latent heat of steam.
t = the quantity of heat necessary to raise the water in tanks from its mean temperature to that at which it is evaporated.
t' = the quantity of heat necessary to raise the initial to the final temperature of the water in the boiler.
t'' = the quantity of heat necessary to raise water at the temperature of tanks to the final temperature of water in boiler.
P = the weight of coal consumed during experiment.
E' = the coefficient of the evaporative power of coal.

But when the initial is lower than the final temperature, the formula becomes

$$\frac{(W - Eq + w - w')\,l + Wt + wt' + (w' - w)\,t'''}{Pl} = E'$$

in which all the terms retain their original value except the last, in which t'' is replaced by t''', which is the quantity of heat necessary to raise the final temperature to that at which the water was evaporated, and must be regarded as having a negative value, whilst t' becomes positive.

The combustible matter in the cinder ash and soot has been estimated as described in the First Report, and the calculations made by the same formulæ, thus:—If Q be the weight of coal containing the same weight of combustible matter as the residua after combustion in the furnace, we have

$$\frac{(W - Eq + w - w')\,l + (W + w - w')\,t + wt' + (w' + w)\,t''}{(P - Q)\,l} = E''$$

and

$$\frac{(W - Eq + w - w')\,l + Wt + wt' + (w' - w)\,t'''}{(P - Q)\,l} = E'';$$

E'' being the corrected coefficient of the evaporative power of coal.

Let then w_1 = the weight of ashes after experiment,
" w_2 " cinder "
" w_3 " soot "
The weight of cinder is taken after the separation of the clinker.

Let r_1, r_2, r_3 be the respective percentages of combustible matter in the ash, cinder, and soot.
" Q the weight of coal containing the same weight of combustible matter.
" r the percentage of combustible matter as found in the coal by analysis.

Then $r\,Q = r_1 w_1 + r_2 w_2 + r_3 w_3$,

$$\therefore Q = \frac{r_1 w_1 + r_2 w_2 + r_3 w_3}{r}$$

TABLE I.—Showing the EXPANSION of WATER in the BOILER at different TEMPERATURES,

Temperature of Water, Fahr.	Ratio of Apparent to Real Weight.	Actual Weight of Water in Boiler when filled to Normal Point.	Difference between Actual and Apparent Weight.	Temperature of Water, Fahr.	Ratio of Apparent to Real Weight.	Actual Weight of Water in Boiler when filled to Normal Point.	Difference between Actual and Apparent Weight.
°		lbs.		°		lbs.	
70	1·0000	4730·000	0·000	170	0·9940	4701·620	28·380
80	0·9996	4728·108	1·892	180	0·9923	4693·579	36·421
90	0·9992	4726·216	3·784	190	0·9901	4683·173	46·827
100	0·9987	4723·950	6·050	200	0·9879	4672·767	57·233
110	0·9983	4721·960	8·040	202	0·9869	4668·037	61·963
120	0·9979	4719·097	10·903	204	0·9859	4663·307	66·693
130	0·9974	4717·795	12·205	206	0·9849	4658·577	71·423
140	0·9971	4715·283	14·717	208	0·9839	4653·847	76·153
150	0·9967	4714·012	15·988	210	0·9829	4649·117	80·883
160	0·9954	4708·242	21·758	212	0·9819	4644·387	85·613

TABLE 2.

Air Thermometer Centigrade.	Mercurial Centigrade.	Number of Unities of Heat abandoned by one Pound of Water in descending from T to O°	Air Thermometer Fahrenheit.	Mercurial Fahrenheit.	Number of Unities of Heat contained in One Pound of Water at T°.	Mean Specific Heat of Water between O° and T cent., or between 32° and T Fahrenheit.	Specific Heat of Water from T to T + d T.	Latent Heat of Vapour Saturated to the Temperature T.	
								Centigrade.	Fahrenheit.
°	°		°	°					
0	..	0·000	32	..	32·000	..	1·0000	606·5	1091·7
10	..	10·002	50	..	50·003	1·0002	1·0005	599·5	1079·1
20	..	20·010	68	..	68·018	1·0005	1·0012	592·6	1066·7
30	..	30·026	86	..	86·046	1·0009	1·0020	585·7	1054·2
40	..	40·051	104	..	104·091	1·0013	1·0030	578·7	1041·6
50	50·2	50·087	122	122·36	122·156	1·0017	1·0042	571·6	1028·9
60	..	60·137	140	..	140·246	1·0023	1·0056	564·7	1016·4
70	..	70·210	158	..	158·381	1·0030	1·0072	557·6	1003·7
80	..	80·282	176	..	176·507	1·0035	1·0089	550·6	990·1
90	..	90·381	194	..	194·685	1·0042	1·0109	543·5	978·3
100	100·0	100·500	212	212·0	212·900	1·0050	1·0130	536·5	965·7
110	..	110·641	230	..	231·153	1·0058	1·0153	529·4	952·9
120	..	120·806	248	..	249·450	1·0067	1·0177	522·3	940·1
130	..	130·997	266	..	267·794	1·0076	1·0204	515·1	927·2
140	..	141·215	284	..	286·187	1·0087	1·0232	508·0	914·4
150	150·0	151·462	302	302·0	304·632	1·0097	1·0262	500·7	901·2
160	..	161·741	320	..	323·133	1·0109	1·0294	493·6	888·5
170	..	172·052	338	..	341·693	1·0121	1·0328	486·2	875·1
180	..	182·398	356	..	360·316	1·0133	1·0364	479·0	862·2
190	..	192·779	374	..	379·002	1·0146	1·0401	471·6	848·9
200	200·0	203·200	392	392·0	397·760	1·0160	1·0440	464·3	835·7
210	..	213·660	410	..	416·588	1·0174	1·0481	456·8	822·2
220	..	224·162	428	..	435·480	1·0189	1·0524	449·4	808·9
230	..	234·708	446	..	454·474	1·0204	1·0568	441·9	795·4

TABLE 3.—CORRECTION for EXPANSION and CONTRACTION of WATER in the TANKS taking 70° as the Normal Temperature.

Temperature Fahrenheit.	Actual Weight of an Unity of Water.	Temperature Fahrenheit.	Actual Weight of an Unity of Water.
°		°	
40	1·001464	62	1·000712
42	1·001451	64	1·000534
44	1·001439	66	1·000356
46	1·001426	68	1·000178
48	1·001414	70	1·000000
50	1·001401	72	·999763
52	1·001294	74	·999527
54	1·001196	76	·999290
56	1·001094	78	·999054
58	1·000992	80	·998818
60	1·000890		

Willington Coal.

I HEREBY certify that the three boxes marked No. 2 contain a fair sample of the Willington Colliery Coals, which were mined specially for the service of the "Admiralty Coals investigation."—WILLIAM GREEN, *Agent to the Northern Coal Mining Company.*

This colliery is situated on the Main Coal Seam in the township of Willington, parish of Brancepeth, eight miles south-west of the city, and in the county of Durham. The present depth of the mine is 40 fathoms, where the thickness of the seam varies from 3 feet 10 inches to 4 feet 2 inches. The coal is extracted by the board and pillar system, and the overlying and subjacent strata consist of sandstone and soft clay, the former being immediately above and the latter directly under the vein, which dips to the east at the rate of 1½ inches per yard.

The coal, which is soft, is considered to be of excellent quality for the manufacture of coke, large quantities of which are prepared on the mine, and from thence supplied to various English and foreign railway companies for the consumption of their locomotives, for which purpose it is stated to have given general satisfaction.

The shipping ports are Clare and Middlesborough, on the river Tees, which are respectively situated at a distance of 24½ miles from the mine, and where the coals are sold at 6*s.* per ton delivered on board ship.

The specimen which was sent up for trial was so soft that it had become almost reduced to powder during its transit to Putney, and its physical characters were therefore not easily examined. On the fire it was found to be excessively bituminous, running together and choking the draught, so as to require constant attention in order to keep up the steam.

It was also found to light with difficulty and give off much smoke when stirred. The clinker, which was very brittle, did not stick to the bars, but on the whole this coal appears much better adapted for coking than for the purposes of the steam navy.

	June 14, 1st day.	June 15, 2nd day.	June 16, 3rd day.
Fire lighted	9 h. 0 m.	9 h. 10 m.	9 h. 0 m.
Steam up	9 h. 15 m.	9 h. 35 m.	9 h. 20 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	206°	205°
Temperature of water in tanks	65°	62°	64°
Barometer	30·20 in.	29·92 in.	29·87 in.
Extremes of external thermometer	47°—69°	52°—70°	47°—70°
Extremes of internal thermometer	59°—70°	65°—71°	63°—71°
Dewpoint	49°	52°	54°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	508 lbs.	358 lbs.	398 lbs.
Weight of ashes left	18 lbs.	11 lbs.	11 lbs.
Per centage of combustible matter in ashes	27·7	30·1	31·1
Weight of cinder left	8 lbs.	9 lbs.	9 lbs.
Per centage of combustible matter in cinder	54·5	75·7	37·2
Weight of clinker in cinder	1 lb.	1 lb.	2 lbs.
Average weight of soot in flues	0·34 lb.	0·34 lb.	0·34 lb.
Per centage of combustible matter in soot	66·0	..	..
Weight of water evaporated	4550 lbs.	3040 lbs.	3530 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	10·25 lbs.	9·70 lbs.	9·92 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·70 lbs.	8·95 lbs.	9·95 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	..	..	..
Mean weight of cubic foot of coal	53·16 lbs.	..	..
Economic weight or space occupied by 1 ton	42·10 ft.	..	..
Cohesive power of coal	43·0	..	..

Note.—Final temperature on fourth morning, 191°.

Bowden Close Coal.

I HEREBY certify that the three boxes marked No. 3 contain a fair sample of the Bowden Close Colliery Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM GREEN, *Agent for the Northern Coal Mining Company.*

This mine, which, like the preceding, is the property of the Northern Coal Mining Company, is situated in the township of Helmington, parish of Brancepeth, eight miles west of the city of Durham. The coal is at present worked at a depth of 55 fathoms from the surface, and is described as "tender, easily wrought, and suitable for manufacturing purposes."

The vein, which is on an average 3 feet 6 inches in thickness, is irregular, and has a dip 1½ inches per yard to the south-east. The extraction is carried on by the board and pillar system, and the coals are carried a distance of 27 miles to Hartlepool, where they

are shipped for various parts of the coast, as well as for the continental markets. The present selling price is 6*s.* per ton on board ship.

This, like the foregoing, is a soft, bituminous coal, which cakes on the bars and impedes the draught. It however possesses these properties in a less degree than the Willington coals, and is therefore better fitted for furnace purposes, although it gives off dense volumes of smoke on stoking the fire, and requires constant attention in order to keep up the steam.

	June 18, 1st day.	June 19, 2nd day.	June 20, 3rd day.
Fire lighted	8 h. 50 m.	9 h. 0 m.	8 h. 45 m.
Steam up	9 h. 30 m.	9 h. 25 m.	9 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	191°	208°	209°
Temperature of water in tanks	64°	62°	68°
Barometer	30·01 in.	29·92 in.	30·24 in.
Extremes of external thermometer	50°—71°	49°—70°	54°—70°
Extremes of internal thermometer	64°—72°	65°—70°	66°—71°
Dewpoint	50°	48°	51°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	554 lbs.	362 lbs.	440 lbs.
Weight of ashes left	12 lbs.	14 lbs.	16 lbs.
Per centage of combustible matter in ashes	38·0	48·7	34·8
Weight of cinder left	6 lbs.	9 lbs.	13 lbs.
Per centage of combustible matter in cinder	63·3	80·0	86·6
Weight of clinker in cinder	2 lbs.	1 lb.	1 lb.
Average weight of soot in flues	0·34 lb.	0·34 lb.	0·34 lb.
Per centage of combustible matter in soot	56·8	..	..
Weight of water evaporated	3940 lbs.	3200 lbs.	3740 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·34 lbs.	10·14 lbs.	9·70 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·85 lbs.	9·05 lbs.	11·00 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	..	..	..
Mean weight of cubic foot of coal	50·66 lbs.	..	..
Economic weight or space occupied by 1 ton	44·26 ft.	..	..
Cohesive power of coal	38·5	..	..

Note.—Final temperature on fourth morning, 210°.

Wigan Four-Foot Seam.

I HEREBY certify that the two casks marked Wigan Four-Foot contain a fair sample of the Wigan Four-Foot Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—W. H. BRANCHER and Co., *Proprietors.*

These coals are mined from the Four-Foot seam, situated at Walthen House, two miles from Wigan. The vein varies from 3 feet 8 inches to 4 feet 6 inches in thickness, and is worked at a depth of 176 yards from the surface, where the dip is from 1 in 15 to 1 in 20 towards the south. The overlying and subjacent strata are described as consisting of "inferior black band," and the coals are represented as "rather bituminous and slow-burning, very suitable for steam navigation, leaving a white ash, and worked large."

The colliery is conducted by the board and wall system, and its produce is principally conveyed to Liverpool, where it has been chiefly carried by the Leeds and Liverpool Canal at an expense of 2*s.* 7½*d.* per ton.

The distance of the colliery from the shipping port is 33 miles, and the principal markets for the coals are Liverpool, Manchester, and Ireland.

The present current price at the mine pier varies from 5*s.* 6*d.* to 6*s.* per ton, whilst at Liverpool from 9*s.* to 9*s.* 6*d.* per ton is charged to the shipping, and 10*s.* 6*d.* to private individuals, who employ it as an inferior kind of household coal.

In appearance it resembles the other specimens from the same district, having a cubical fracture, and containing a large quantity of the shaly matter so often referred to in the Second Report.

Under the boiler this coal was found to light readily and blow off the steam rapidly; it however gives off much black smoke, and leaves a considerable amount of whitish ash and clinker, which does not attach itself to the bars. A strong draught is required with this coal, as with one of feeble intensity a very "dirty" fire is obtained.

	June 21, 1st day.	June 22, 2nd day.	June 23, 3rd day.
Fire lighted	9 h. 35 m.	9 h. 20 m.	9 h. 10 m.
Steam up	9 h. 50 m.	9 h. 45 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	210°	207°	204°
Temperature of water in tanks	68°	68°	72°
Barometer	30·20 in.	30·15 in.	30·00 in.
Extremes of external thermometer	51°—78°	54°—80°	54°—80°
Extremes of internal thermometer	68°—78°	68°—79°	69°—82°
Dewpoint	58°	59°	59°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	551 lbs.	419 lbs.	458 lbs.
Weight of ashes left	23 lbs.	18 lbs.	17 lbs.
Per centage of combustible matter in ashes	50·9	19·6	37·4
Weight of cinder left	5 lbs.	14 lbs.	12 lbs.
Per centage of combustible matter in cinder	81·3	88·7	79·0
Weight of clinker in cinder	11 lbs.	6 lbs.	7 lbs.
Average weight of soot in flues	·34 lb.	·34 lb.	·34 lb.
Per centage of combustible matter in soot	76·0	..	..
Weight of water evaporated	4255 lbs.	2710 lbs.	2990 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·77 lbs.	7·306 lbs.	7·26 lbs.
Weight of coals per hour for one square foot of grate surface	13·77 lbs.	10·47 lbs.	11·45 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·209	..	..
Mean weight of cubic foot of coal	53·41 lbs.	..	.
Economic weight or space occupied by 1 ton	41·94 ft.	..	.
Cohesive power of coal	75·0	..	..

Note.—Final temperature on fourth morning, 194°.

King Coal.

I HEREBY certify that the three casks marked King Coal contain a fair sample of the King Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—W. H. BRANCHER and Co., *Proprietors.*

This colliery, like the foregoing, is situated at Walthen House, near Wigan, and is worked on what is called the Top Seam, 2 feet in thickness, and the Lower Seam, 1 foot 6 inches in thickness, both very regular.

These veins are at present wrought at a depth of 293 yards from the surface, where they have an inclination of from 1 in 15 to 1 in 20 towards the south. The overlying and subjacent strata produce Cannel coal.

The principal markets for these coals are the same as for that last described, but from being considered to be of superior quality, they fetch a higher price, viz., 8*s.* 6*d.* per ton at the colliery, and 15*s.* at Liverpool, where they are employed as superior house coals.

In appearance they resemble the Wigan Four-Foot, but contain a larger quantity of mineralized charcoal and less white shale.

This variety, like the preceding, lights readily and blows off the steam rapidly, but gives off much smoke and deposits large quantities of soot in the flues. The ash is of a reddish colour, the clinker attaches itself firmly to the bars, and a good fire cannot be obtained except with a moderately strong draught.

	June 25, 1st day.	June 26, 2nd day.	June 27, 3rd day
Fire lighted	9 h. 30 m.	9 h. 0 m.	8 h. 25 m.
Steam up	9 h. 50 m.	9 h. 25 m.	8 h. 45 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	194°	206°	210°
Temperature of water in tanks	70°	70°	68°
Barometer	30·10 in.	30·09 in.	30·05 in.
Extremes of external thermometer	57°—76°	56°—76°	53°—76°
Extremes of internal thermometer	68°—78°	70°—78°	66°—78°
Dewpoint	56°	55°	58°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	543 lbs.	352 lbs.	436 lbs.
Weight of ashes left	24 lbs.	19 lbs.	22 lbs.
Per centage of combustible matter in ashes	28·2	10·2	5·8
Weight of cinder left	17 lbs.	9 lbs.	13 lbs.
Per centage of combustible matter in cinder	19·5	46·1	60·1
Weight of clinker in cinder	10 lbs.	7 lbs.	11 lbs.
Average weight of soot in flues	·66 lb.	·66 lb.	·66 lb.
Per centage of combustible matter in soot	55·0	..	..
Weight of water evaporated	3820 lbs.	2570 lbs.	3000 lbs.

	June 25, 1st day.	June 26, 2nd day.	June 27, 3rd day.
Weight of water evaporated from 212° by 1 lb. of coal	8·15 lbs.	8·36 lbs.	8·00 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·57 lbs.	8·80 lbs.	10·90 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·300	..	..
Mean weight of cubic foot of coal	50·83 lbs.	..	..
Economic weight or space occupied by 1 ton	44·09 ft.	..	..
Cohesive power of coal	78·5	..	..

Note.—Final temperature on fourth morning, 204°.

Ewloe Coal.

I HEREBY certify that the four casks marked E W contain a fair sample of the Ewloe Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RIGBY and HANCOCK, *Proprietors.*

The Ewloe Colliery is situated in the townships of Ewloe, Aston, and Shotton, in the parish of Hawarden, Flintshire. The depth of the pit is 160 yards; the thickness of the seam varies from 8 to 10 feet; the overlying and subjacent strata are composed of shale, which together with the vein has an inclination of 1 in 5 towards the east.

These coals are described as "strong and free-burning, not binding, and leaving a white ash."

The principal markets are Chester, the coast of Wales, Isle of Man, Liverpool, and Holyhead.

The specimen sent up for the purposes of the Investigation was a splinty coal of a brown-black colour, containing large quantities of mineralized charcoal and iron pyrites, although less white shale was observed than usually occurs in coals from this part of England.

Under the boiler it lights readily and blows off steam rapidly, and with a quick draught makes a good clear fire, which leaves but little clinker or ash. With a slow draught, on the contrary, it produces large quantities of smoke and soot, which speedily choke the flues, and a considerable amount of ash and cinder remains on the bars.

	June 28, 1st day.	June 29, 2nd day.	June 30, 3rd day.
Fire lighted	11 h. 25 m.	9 h. 5 m.	9 h. 10 m.
Steam up	11 h. 45 m.	9 h. 20 m.	9 h. 25 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	204°	211°	210°
Temperature of water in tanks	68°	66°	68°
Barometer	30·15 in.	30·15 in.	30·17 in.
Extremes of external thermometer	55°—73°	58°—73°	46°—73°
Extremes of internal thermometer	68°—74°	66°—73°	57°—74°
Dewpoint	56°	55°	53°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	604 lbs.	376 lbs.	411 lbs.
Weight of ashes left	7 lbs.	13 lbs.	14 lbs.
Per centage of combustible matter in ashes	47·3	26·7	23·6
Weight of cinder left	7 lbs.	11 lbs.	9 lbs.
Per centage of combustible matter in cinder	51·4	64·0	54·7
Weight of clinker in cinder	1 lb.	·75 lb.	1 lb.
Average weight of soot in flues	·66 lb.	·66 lb.	·66 lb.
Per centage of combustible matter in soot	90·0	..	..
Weight of water evaporated	3935 lbs.	2390 lbs.	2410 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·51 lbs.	7·21 lbs.	6·34 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·10 lbs.	9·40 lbs.	10·27 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·275	..	..
Mean weight of cubic foot of coal	50·41 lbs.	..	..
Economic weight or space occupied by 1 ton	44·44 ft.	..	..
Cohesive power of coal	84·0	..	..

Note.—Final temperature on fourth morning, 190°.

Cadoxton Coal.

I HEREBY certify that the nine casks marked C. DX. N. contain a fair sample of the Cadoxton Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—W. M. MAXWELL, *Proprietor.*

The Cadoxton Colliery is situated near Cadoxton church, at a short distance from the town of Neath, and is worked by level to a depth of 70 yards from the surface, where the

vein, which is very regular, and 3 feet 6 inches in thickness, is divided into two parts by a band of stone. The seam has a dip of 4 inches in the yard from east to west, and is covered by argillaceous shale.

The mine is worked by first driving a cross-heading, and then opening and working heads in the level, leaving a pillar of 4 yards on the land side of the deep level road.

The coal, which is described by the proprietor as "Free-burning or Steam Coal," is shipped at Swansea, where the current prices are as follows:—Handpicked, 10*s.*; through and through, 6*s.* 6*d.*; and small, 3*s.* 6*d.* per ton.

The specimen sent to Putney for trial was excessively soft, but presented in a marked degree the peculiar radiated appearance observed in other varieties of South Wales coals.

Under the boiler it was found to light with such difficulty as to make it necessary to prolong the experiment over the space of 24 hours, in order to avoid the inconvenience and loss of heat incident on three successive lightings, which, from the time necessary to get up the steam, would have materially influenced the results obtained. Even with these advantages, however, a very bad fire was produced, as the small coal continually choked the draught-ways between the bars; or, on being stoked, ran through into the ash-pit, so as to render this coal far from desirable for use under steam-boilers. No smoke was however produced; and the bad quality of the coal seemed rather to arise from its great softness, and the consequent finely divided state to which it had become reduced, than to any defect in the composition of the fuel itself. The clinker formed was soft, and adhered to the bars.

—	July 5 and 6.
Fire lighted	9 h. 45 m.
Steam up	11 h. 30 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	190°
Temperature of water in tanks	70°
Barometer	30·16 in.
Extremes of external thermometer	54°—76°
Extremes of internal thermometer	62°—78°
Dewpoint	55°
Area of damper open	112 in.
Weight of coals consumed	1032 lbs.
Weight of ashes left	146 lbs.
Per centage of combustible matter in ashes	70·0
Weight of cinder left	20 lbs.
Per centage of combustible matter in cinder	81·8
Weight of clinker in cinder	16 lbs.
Average weight of soot in flues	None
Per centage of combustible matter in soot	..
Weight of water evaporated	8260 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·97 lbs.
Weight of coals per hour for 1 square foot of grate surface	8·60 lbs.
Duration of experiment	24 hrs.
Specific gravity of coal	1·378
Mean weight of cubic foot of coal	57·99 lbs.
Economic weight or space occupied by 1 ton	38·55 ft.
Cohesive power of coal	..

Note.—Final temperature, 158°.

Ince Hall Pemberton Four-feet Coal.

I HEREBY certify that the four casks marked P $\frac{4}{}$ 1 to 4 contain a fair sample of the Pemberton Four-feet Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WM. LANCASTER, *Managing Partner of the Ince Hall Coal and Cannel Company.*

The colliery from which this coal was extracted is situated in the township of Ince, in Mackerfield, near Wigan, county of Lancaster. The vein is 4 feet 4 inches in thickness, and regular, with a dip of 1 in 7 towards the east. The overlying and subjacent strata are composed of grey rock and fire-clay, the former being above and the latter below the seam. The mine is worked by pillars and stalls, and is at present carried to the depth of 200 yards, where it yields a coal which is described as "very clean and open-burning, used for house and steam purposes." The principal markets are Liverpool, Preston, and Fleetwood; where the current price varies from 8*s.* 6*d.* to 9*s.* 3*d.* per ton delivered on board. The coal sells at the pit's mouth for 6*s.* per ton.

This coal-field is a trough of 1400 yards in breadth, lying between two parallel faults running 23° west of north and east of south.

The coal is rather hard and brilliant, and contains considerable quantities of white shale, though but little iron pyrites was observed. During our trials it was found to light readily, and get the steam up rapidly, producing a good clear fire, which required little

stoking, and left but a small quantity of ash and clinker. A considerable amount of smoke was however evolved during its combustion, and much soot was deposited in the flues.

	July 9, 1st day.	July 10, 2nd day.	July 11, 3rd day.
Fire lighted	9 h. 30 m.	8 h. 40 m.	9 h. 20 m.
Steam up	10 h. 10 m.	8 h. 55 m.	9 h. 55 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	158°	212°	208°
Temperature of water in tanks	76°	74°	74°
Barometer	30·35 in.	30·40 in.	30·37 in.
Extremes of external thermometer	57°—78°	55°—77°	56°—76°
Extremes of internal thermometer	76°—82°	74°—81°	74°—81°
Dewpoint	57°	56°·5	56°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	718 lbs.	385 lbs.	499 lbs.
Weight of ashes left	9 lbs.	19 lbs.	9 lbs.
Per centage of combustible matter in ashes	23·7	32·0	25·0
Weight of cinder left	12 lbs.	incl. in ash.	5 lbs.
Per centage of combustible matter in cinder	58·0	..	77·7
Weight of clinker in cinder	1 lb.	·5 lb.	none
Average weight of soot in flues	·33 lb.	·33 lb.	·33 lb.
Per centage of combustible matter in soot	70·2	..	..
Weight of water evaporated	4680 lbs.	2900 lbs.	3860 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·84 lbs.	8·45 lbs.	8·75 lbs.
Weight of coals per hour for 1 square foot of grate surface	17·95 lbs.	11 lbs.	12·47 lbs.
Duration of experiment	8 hrs.	7 hrs.	8 hrs.
Specific gravity of coal	1·276	..	..
Mean weight of cubic foot of coal	51·83 lbs.	..	..
Economic weight, or space occupied by 1 ton	43·24 ft.	..	..
Cohesive power of coal	74·5	..	..

Note.—Final temperature on fourth morning, 206°.

Ince Hall Pemberton Five-feet Coal.

I HEREBY certify that the four boxes marked P (5) 5, 6, 15, 16, contain a fair sample of the Pemberton Five-Feet Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WM. LANCASTER.

This mine, which is 180 yards in depth, is situated in the immediate neighbourhood of the foregoing, and the produce consequently finds the same markets. The vein is 5 feet in thickness, and very regular, with a dip of 1 in 7 towards the east. The overlying strata are composed of blue shale, and the subjacent of fire-clay.

The screened coals at the pit are sold for 5*s.* 6*d.*; free on board at Liverpool, 8*s.*; ditto at Preston, 7*s.* 1*d.*; and shipped at Fleetwood, 8*s.* 9*d.* per ton. In appearance they resemble those from the "Four Feet Seam;" containing, however, more brown shale and iron pyrites. Under the boiler these coals were found to light easily and burn freely, yielding for some time a good clear fire. After the expiration of a few hours, however, the draught-ways of the grate became choked, from an accumulation of a very fusible clinker, which attached itself so firmly to the bars as not to be removed without extreme difficulty. Considerable quantities of smoke were evolved during the experiments, and a rather large proportion of ash and clinker remained at their termination.

	August 16, 1st day.	August 17, 2nd day.	August 18, 3rd day.
Fire lighted	9 h. 15 m.	8 h. 40 m.	8 h. 35 m.
Steam up	9 h. 30 m.	9 h. 10 m.	9 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	207°	207°	210°
Temperature of water in tanks	64°	64°	64°
Barometer	29·85 in.	29·97 in.	29·98 in.
Extremes of external thermometer	49°—66°	50°—68°	47°—69°
Extremes of internal thermometer	63°—67°	64°—69°	66°—70°
Dewpoint	52°	52°	53°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	714 lbs.	461 lbs.	575 lbs.
Weight of ashes left	29 lbs.	37 lbs.	19 lbs.
Per centage of combustible matter in ashes	23·3	20·6	16·00
Weight of cinder left	40 lbs.	incl. in ash.	10 lbs.
Per centage of combustible matter in cinder	55·4	..	45·5
Weight of clinker in cinder	5 lbs.	6 lbs.	5 lbs.
Average weight of soot in flues	·33 lb.	·33 lb.	·33 lb.

	August 16, 1st day.	August 17, 2nd day.	August 18, 3rd day.
Per centage of combustible matter in soot	65·0	..	..
Weight of water evaporated	4770 lbs.	3055 lbs.	4060 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·66 lbs.	7·62 lbs.	7·90 lbs.
Weight of coals per hour for 1 square foot of grate surface	17·85 lbs.	11·52 lbs.	14·37 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·269	..	..
Mean weight of cubic foot of coal	51·83 lbs.	..	..
Economic weight, or space occupied by 1 ton	43·24 ft.	..	..
Cohesive power of coal	71·5	..	..

Note.—Final temperature on fourth morning, 194°.

Ince Hall Pemberton Yard Coal.

I HEREBY certify that the four boxes marked (Y) 11 to 14 inclusive contain a fair sample of the Pemberton Yard Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WM. LANCASTER.

This coal is raised in the same township as the two foregoing varieties. The pit is situated near the canal in the township of Ince, and its produce is disposed of at the same markets as that of the Four and Five Feet seams. The current price for screened coal is at the pit 6*s.* 6*d.*; free on board at Liverpool, 9*s.*; at Preston, 8*s.* 6*d.*; and at Fleetwood, 9*s.* 9*d.* per ton.

The vein varies in thickness from 32 inches to 3 feet; and has a roof of blue shale, and a hard floor, with an inclination of about 1 in 7, a few points to the north of east.

"This coal-field is a belt of 1100 yards, interposed between two parallel faults running nearly north and south;" and the mine, being quite free from water, requires no hydraulic machinery. The coal, which is of a full black colour, with a cubical fracture, contains but little shaly matter or iron pyrites, and is stated to be chiefly employed for steam purposes and the manufacture of coke. When tried under the experimental boiler, it was found to light easily, and produce a good clear fire, although large quantities of smoke were evolved from the chimney, particularly on stirring the fire.

In stoking this coal it is merely necessary to work it regularly back from the dead-plate. The amount of ash and clinker left was not considerable; and the latter, being infusible, and therefore not attacking the bars, did not interfere with the draught-ways of the grate.

	August 20, 1st day.	August 21, 2nd day.	August 22, 3rd day.
Fire lighted	8 h. 45 m.	9 h. 15 m.	9 h. 35 m.
Steam up	9 h. 5 m.	9 h. 25 m.	9 h. 45 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	194°	210°	211°
Temperature of water in tanks	66°	68°	66°
Barometer	30·20 in.	30·25 in.	30·30 in.
Extremes of external thermometer	58°—70°	62°—73°	60°—72°
Extremes of internal thermometer	68°—71°	70°—74°	71°—74°
Dewpoint	57°	58°·5	59°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	601 lbs.	368 lbs.	479 lbs.
Weight of ashes left	9 lbs.	16 lbs.	17 lbs.
Per centage of combustible matter in ashes	7·2	41·5	14·1
Weight of cinder left	10 lbs.	6 lbs.	5 lbs.
Per centage of combustible matter in cinder	65·8	80·5	88·4
Weight of clinker in cinder	4 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	·33 lb.	·33 lb.	·33 lb.
Per centage of combustible matter in soot	63·2	..	..
Weight of water evaporated	4500 lbs.	2690 lbs.	3880 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·74 lbs.	8·33 lbs.	9·27 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·02 lbs.	9·20 lbs.	11·97 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·348	..	..
Mean weight of cubic foot of coal	47·90 lbs.	..	..
Economic weight or space occupied by 1 ton	46·66 ft.	..	..
Cohesive power of coal	75·5	..	..

Note.—Final temperature on fourth morning, 212°.

Ince Hall Company's Furnace Vein Coals.

I HEREBY certify that the four boxes marked (F) 7 to 10 contain a fair sample of the Furnace Vein Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WM. LANCASTER.

This coal, like the three preceding varieties, is the property of the Ince Hall Coal Company, and is situated in the township of Ince, near Wigan. The seam from which it is raised is 5 feet in thickness, and very regular, having an inclination of about 1 in 7 towards the east. The roof is composed of shale, and the floor of soft fire-clay. The working, as in the other cases, is conducted by means of stalls and pillars, and the produce shipped at the same ports as that of the other Ince Hall collieries.

The coal is described as "free from sulphur, strong, and leaving but little ash, not affected by keeping, and much used for steam purposes, glass-houses, and iron-forges." The present current prices are as follows:—At the pit's mouth, 5*s.* 6*d.*; free on board at Liverpool, 8*s.*; delivered at Preston, 7*s.* 6*d.*; and at Fleetwood, 8*s.* 9*d.* per ton.

In appearance this coal differs from the three preceding varieties, in being less bright, and containing more brown shale. In the furnace it lights easily, but evolves much smoke, and leaves a large quantity of ash and clinker of a whitish colour, which obstructs the draught, and requires the frequent use of the rake, by which it may be removed without difficulty, as it does not melt or adhere to the bars. A quick draught is required in order to keep up a good fire; as with a slow one the furnace becomes very troublesome to manage, and the combustion sluggish.

On the third day some of the fire-bars fell out, which obliged us to limit the duration of the experiment to seven hours; and from the frequent opening of the fire-doors, in attempting to replace them, and the consequent cooling down of the whole apparatus, it is probable that the results obtained on that day may be rather lower than they would have been under ordinary circumstances.

	August 23, 1st day.	August 24, 2nd day.	August 25, 3rd day.
Fire lighted	9 h. 30 m.	9 h. 35 m.	9 h. 0 m.
Steam up	9 h. 40 m.	9 h. 55 m.	9 h. 10 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	212°	210°	210°
Temperature of water in tanks	66°	68°	68°
Barometer	30·23 in.	30·22 in.	30·25 in.
Extremes of external thermometer	59°—73°	59°—72°	59°—75°
Extremes of internal thermometer	70°—74°	70°—73°	69°—75°
Dewpoint	61°	57°	58°
Area of damper open	112 in.	56 in.	168 in.
Weight of coals consumed	545 lbs.	429 lbs.	526 lbs.
Weight of ashes left	26 lbs.	17 lbs.	25 lbs.
Per centage of combustible matter in ashes	74·7	75·6	73·1
Weight of cinder left	12 lbs.	13 lbs.	incl. in ash
Per centage of combustible matter in cinder	79·0	66·6	..
Weight of clinker in cinder	7 lbs.	3 lbs.	7 lbs.
Average weight of soot in flues	·33 lb.	·33 lb.	·33 lb.
Per centage of combustible matter in soot	63·7	..	..
Weight of water evaporated	3820 lbs.	2640 lbs.	3550 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·44 lbs.	7·00 lbs.	7·98 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·82 lbs.	10·72 lbs.	15·02 lbs.
Duration of experiment	8 hrs.	8 hrs.	7 hrs.
Specific gravity of coal	1·314	..	..
Mean weight of cubic foot of coal	49·33 lbs.	..	..
Economic weight or space occupied by 1 ton	45·43 ft.	..	..
Cohesive power of coal	71·5	..	..

Note.—Final temperature on fourth morning, 190°.

Hollands and Green's Patent Fuel.

I HEREBY certify that the artificial fuel sent herewith is a fair sample of Hollands and Green's Patent Fuel, which was manufactured specially for the service of the "Admiralty Coals Investigation."—HOLLANDS AND GREEN, *Patentees.*

This fuel is made into blocks 5 inches square, and has the following composition:—

Lime	100 parts
Gypsum	17 ,,
Alum	17 ,,
Common salt	17 ,,
Aluminous clay	28 ,,
Screenings of Newcastle coal	2240 ,,

These ingredients are manufactured into fuel by first grinding the lime, gypsum, alum, and salt, and adding them in a dry state to the coal. The clay is then mixed with about

20 gallons of water, and thrown on the prepared coal, which is moulded into bricks either by hand or by the aid of machinery.

Under the boiler this fuel was found at first to light easily and produce a good fire; but as the experiment proceeded, the bars became choked from the great accumulation of clinker, arising from the quantity of foreign matters added to the coal, and which cannot fail to produce very large amounts of clinker and ash. The lime and gypsum are evidently added for the purpose of cementing together the particles of coal; but the motive for the addition of alum and common salt is far from obvious, as their only tendency must be to greatly increase the amount of clinker formed.

On the first day of the experiments the blocks were each broken into three or four pieces and then stoked as ordinary coal. On the second day, however, the blocks were charged whole on the dead-plate, and then gradually worked back with the rake, which has the advantage of producing a clear fire, which gives off less smoke than that obtained by the first method.

	August 27, 1st day.	August 28, 2nd day.	August 29, 3rd day.
Fire lighted	9 h. 45 m.	9 h. 5 m.	9 h. 45 m.
Steam up	10 h. 30 m.	9 h. 15 m.	9 h. 55 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	190°	211°	212°
Temperature of water in tanks	66°	66°	66°
Barometer	30·11 in.	30·07 in.	30·02 in.
Extremes of external thermometer	55°—68°	60°—72°	62°—74°
Extremes of internal thermometer	69°—70°	69°—74°	70°—75°
Dewpoint	53°	52°	59°
Area of damper open	112 in.	168 in.	84 in.
Weight of fuel consumed	537 lbs.	642 lbs.	534 lbs.
Weight of ashes left	35 lbs.	28 lbs.	34 lbs.
Per centage of combustible matter in ashes	17·3	13·7	22·0
Weight of cinder left	16 lbs.	12 lbs.	22 lbs.
Per centage of combustible matter in cinder	65·0	72·4	67·0
Weight of clinker in cinder	21 lbs.	28 lbs.	18 lbs.
Average weight of soot in flues	·33 lb.	·33 lb.	·33 lb.
Per centage of combustible matter in soot	65·0	..	..
Weight of water evaporated	3330 lbs.	4300 lbs.	3650 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	7·33 lbs.	7·67 lbs.	7·77 lbs.
Weight of fuel per hour for 1 square foot of grate surface	13·42 lbs.	16·05 lbs.	13·35 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of fuel	1·302	..	..
Mean weight of cubic foot of fuel	64·84 lbs.	..	..
Economic weight or space occupied by 1 ton	34·56 ft.	..	..
Cohesive power of fuel	..	..	..

Note.—Final temperature on fourth morning, 209°.

Birch Grove Graigola Coal.

I HEREBY certify that the boxes marked respectively 1, 2, 3, 4, 5, 6, 7, 8, contain a fair sample of the Birch Grove Graigola coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM WATSON, *Agent.*

The Birch Grove Colliery is situated 4½ miles N.N.W. of Swansea, which is the shipping port, and from whence the produce is sent to nearly all parts of the world to be employed for steam purposes.

The present depth of the mine is 61 fathoms, and the thickness of the seam (which is tolerably regular) 6 feet. It has an inclination of 4½ inches per yard towards the north-west, and the overlying and subjacent strata are composed of "hard black stone."

The vein is worked by stalls and pillars, and the present current price of the coal is 9*s.* per ton.

This coal presents a brilliant, irregular fracture when broken, and many portions possess that peculiar radiated appearance so often observed in other varieties from the same district. Scarcely any white shale could be detected, but spots of iron pyrites were numerous. During our experiments it was found to light with tolerable ease, producing a good clear fire with little smoke; but being very soft, a considerable portion crumbled on the grate, and fell through the bars. When thrown on the fire or stirred, it burns with scintillation. The clinker is small in quantity, and adheres firmly to the bars.

In the third trial some of the bars fell out just before closing the experiment, which accounts for the large quantity of ash and cinder noted for that day, as also for their being weighed together, and not separately, as is customary in the case of other coals.

	August 30, 1st day.	August 31, 2nd day.	September 1, 3rd day.
Fire lighted	9 h. 30 m.	9 h. 10 m.	10 h. 25 m.
Steam up	9 h. 45 m.	9 h. 30 m.	10 h. 40 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	209°	208°	210°
Temperature of water in tanks	70°	70°	68°
Barometer	29·95 in.	29·94 in.	29·87 in.
Extremes of external thermometer	63°—74°	60°—74°	58°—73°
Extremes of internal thermometer	70°—75°	72°—76°	70°—75°
Dewpoint	54°	55°	53°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	557 lbs.	460 lbs.	469 lbs.
Weight of ashes left	17 lbs.	27 lbs.	56 lbs.
Per centage of combustible matter in ashes	17·3	23·3	71·6
Weight of cinder left	7 lbs.	21 lbs.	incl. in ash.
Per centage of combustible matter in cinder	50·0	44·9	..
Weight of clinker in cinder	3 lbs.	8 lbs.	8 lbs.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4630 lbs.	3680 lbs.	3870 lbs.
Weight of water evaporated from 212° by 1lb. of coal	9·46 lbs.	9·14 lbs.	9·06 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·92 lbs.	11·50 lbs.	11·72 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·360	..	..
Mean weight of cubic foot of coal	51·00 lbs.	..	..
Economic weight, or space occupied by one ton	43·92 ft.	..	..
Cohesive power of coal	59·0	..	..

Note.—Final temperature on fourth morning, 184°.

Ibstock Coal.

I HEREBY certify that the four casks marked No. 1, 2, 3, 4, contain a fair sample of the Ibstock Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM GILL.

The Ibstock Colliery is situated at Ibstock, about 11 miles from the town of Leicester, from whence the coal is sent by canal and railway to various parts of England. It is described as "Mingy, or Cleft Coal, with a cubical fracture, adapted for house purposes, and more particularly for steamers." The mine is 128½ yards in depth, and the vein 8½ feet thick, and tolerably regular. "This coal will not coke, and has been employed by some of the railway companies instead of that fuel. It contains no sulphur, and consequently does not destroy the iron-work of the furnaces."

The vein occurs in fire-clay, and the coal sells at *7s.* 6*d.* per ton at the pit's mouth.

The specimen sent for experiment was of a full black colour, with a cubical fracture, and contained a considerable amount of iron pyrites, and but little white shale.

On the grate it was found to produce a good clear fire, and with careful stoking gave off but little smoke. This coal behaves precisely like an ordinary splint, and with a quick draught leaves a rather large quantity of clinker, which does not however attach itself to the bars.

	September 12 1st day.	September 13, 2nd day.	September 14. 3rd day.
Fire lighted	9 h. 15 m.	9 h. 0 m.	9 h. 10 m.
Steam up	9 h. 35 m.	9 h. 20 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	203°	206°	210°
Temperature of water in tanks	58°	60°	62°
Barometer	29·12 in.	29·90 in.	30·23 in.
Extremes of external thermometer	49°—59°	51°—61°	55°—64°
Extremes of internal thermometer	60°—66°	60°—67°	65°—68°
Dewpoint	52°	53°	53°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	745 lbs.	538 lbs.	544 lbs.
Weight of ashes left	10 lbs.	13 lbs.	12 lbs.
Per centage of combustible matter in ashes	29·9	33·3	27·0
Weight of cinder left	11 lbs.	11 lbs.	6 lbs.
Per centage of combustible matter in cinder	58·7	64·4	46·7
Weight of clinker in cinder	7 lbs.	2 lbs.	3 lbs.
Average weight of soot in flues	·3 lb.	·3 lb.	·3 lb.
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4270 lbs.	3220 lbs.	3410 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	6.63 lbs.	6·92 lbs.	7·18 lbs.
Weight of coals per hour for 1 square foot of grate surface	18·62 lbs.	13·45 lbs.	13·60 lbs.

—	September 12, 1st day.	September 13, nd day.	September 14, 3rd day.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·291	..	..
Mean weight of cubic foot of coal	47·33 lbs.	..	..
Economic weight, or space occupied by 1 ton	47·35 ft.	..	..
Cohesive power of coal	62·0	..	..

Note.—Final temperature on fourth morning, 210°.

Moss Hall Pemberton Four-Feet Coal.

I HEREBY certify that the three casks marked P 4, Nos. 1, 2, 3, contain a fair sample of the Pemberton Four-Feet Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD CHRISTOPHER, *a Proprietor and Agent.*

This coal is raised from the Pemberton Four-Feet Mine at the Moss Hall Colliery, in the township of Ince, parish of Wigan, Lancashire. The depth of the mine is 208 yards, and the vein, which has a regular thickness of 4 feet 6 inches, has an inclination of 1 in 7 towards the east. The subjacent and overlying strata consist of strong metal and hard white rock, and the coal, which is described as "free burning, hot, and clear," is worked by ends and walls. Liverpool is the principal market for the coal, and is distant from the mine 22 miles by railway, and 36 miles by canal. The current price at the pit's mouth is 6*s.* per ton.

The specimen sent up for examination was a very bright coal with a cubical fracture, free from iron pyrites, and containing but little shaly matter, or mineralized charcoal.

During our trials it was found to ignite readily, and produce a good clear fire, which required but little stoking in order to keep the steam briskly blowing off. Little ash or clinker is produced; but large quantities of black smoke are given off during the whole time of combustion.

—	September 20, 1st day.	September 21, 2nd day.	September 25, 3rd day.
Fire lighted	2 h. 15 m.	10 h. 15 m.	8 h. 55 m.
Steam up	2 h. 35 m.	10 h. 25 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	210°	210°	194°
Temperature of water in tanks	58°	60°	60°
Barometer	30·38 in.	30·24 in.	29·95 in.
Extremes of external thermometer	49°—59°	49°—62°	48°—63°
Extremes of internal thermometer	62°—66°	62°—67°	61°—65°
Dewpoint	50°	51°	53°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	606 lbs.	422 lbs.	533 lbs.
Weight of ashes left	8 lbs.	10 lbs.	7 lbs.
Per centage of combustible matter in ashes	31·2	32·2	30·8
Weight of cinder left	5 lbs.	9 lbs.	7 lbs.
Per centage of combustible matter in cinder	73·9	55·8	64·1
Weight of clinker in cinder	2 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	·66 lb.	·66 lb.	·66 lb.
Per centage of combustible matter in soot	89·0	..	..
Weight of water evaporated	4710 lbs.	3170 lbs.	3640 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·96 lbs.	8·62 lbs.	8·00 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·15 lbs.	10·55 lbs.	13·32 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·258	..	..
Mean weight of cubic foot of coal	47·33 lbs.	..	..
Economic weight or space occupied by 1 ton	47·35 ft.	..	..
Cohesive power of coal	71·5	..	..

Note.—Final temperature on third morning, 210°.
Final temperature on fourth morning, 207°.

Moss Hall Pemberton Five-Feet Coal.

I HEREBY certify that the three casks marked P 5, Nos. 1, 2, and 3, contain a fair sample of the Pemberton Five-Feet Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD CHRISTOPHER, *a Proprietor and Agent.*

This colliery is situated in the immediate neighbourhood of the preceding, and like it is worked by the wall and end method, and the produce chiefly sent to Liverpool. The mine is 180 yards in depth, and the vein, which is 5 feet in thickness and very regular, has a dip of 1 in 7 towards the east. The coal (sold at 5*s.* per ton at the pit) is described by the proprietors as "hard, burning moderately freely, and very hot."

In appearance this coal so exactly resembles the foregoing, that it is impossible to distinguish between them. During our experiments it was found to light easily and blow off the steam rapidly for the first few hours; but after a time the bars become charged with a fusible clinker, which adheres so firmly that it cannot be removed whilst the furnace is alight, and consequently the draught-ways are partially choked, and the intensity of the fire is reduced.

At the close of the experiments considerable quantities of ash and clinker remained on the grate, some of the latter being in such small pieces that it could not be separated without considerable difficulty from the former, for the purpose of weighing.

—	October 6, 1st day.	October 10, 2nd day.
Fire lighted	9 h. 15 m.	9 h. 35 m.
Steam up	9 h. 30 m.	10 h. 0 m.
Weight of wood used	10 lbs.	11 lbs.
Initial temperature of water in boiler	207°	197°
Temperature of water in tanks	62°	50°
Barometer	29·93 in.	29·85 in.
Extremes of external thermometer	..	..
Extremes of internal thermometer	56°—65°	39°—50°
Dewpoint	50°	48°
Area of damper open	112 in.	84 in.
Weight of coals consumed	519 lbs.	563 lbs.
Weight of ashes left	12 lbs.	11 lbs.
Per centage of combustible matter in ashes	28·0	31·0
Weight of cinder left	9 lbs.	18 lbs.
Per centage of combustible matter in cinder	60·0	59·0
Weight of clinker in cinder	8 lbs.	8 lbs.
Average weight of soot in flues	·33 lb.	·33 lb.
Per centage of combustible matter in soot	79·1	..
Weight of water evaporated	3245 lbs.	3430 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·09 lbs.	7·17 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·97 lbs.	14·07 lbs.
Duration of experiment	8 hrs.	8 hrs.
Specific gravity of coal	1·283	..
Mean weight of cubic foot of coal	48·33 lbs.	..
Economic weight or space occupied by 1 ton	46·37 ft.	..
Cohesive power of coal	78·5	..

Note.—Final temperature on second morning, 202°.
Final temperature on third morning, 207°.

Moss Hall Co.'s New Mine Coal.

I HEREBY certify that the three casks marked N. M. Nos. 1, 2, 3, contain a fair sample of the New Mine coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD CHRISTOPHER, *a Proprietor and Agent.*

These coals like the foregoing are raised in the township of Ince, parish of Wigan. The vein, which is 4 feet 6 inches in thickness, is divided in the middle by 4 inches of "metal," and has an inclination of 1 in 7 towards the east. The overlying and subjacent strata are composed of warren earth and soft blue metal, and the coals are described as "moderately hard, free-burning, and producing a great heat." The mine, which is worked by end and wall, is 110 yards in depth, and situated at a distance of 22 miles by railway and 36 by canal from Liverpool, which is the principal market for the coal. The present current price is 5*s.* per ton at the pit's mouth.

In appearance this coal resembles the two foregoing varieties, and under the boiler was found to yield very similar results, as may be seen by the following table:—

—	October 11, 1st day.	October 12, 2nd day.	October 13, 3rd day.
Fire lighted	9 h. 35 m.	9 h. 35 m.	9 h. 10 m.
Steam up	9 h. 50 m.	10 h. 5 m.	9 h. 35 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	207°	200°	204°
Temperature of water in tanks	52°	52°	52°
Barometer	29·58 in.	29·60 in.	29·84 in.
Extremes of external thermometer	44°—54°	41°—53°	40°—49°
Extremes of internal thermometer	55°—62°	54°—67°	53°—58°
Dewpoint	44°	43°	41°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	606 lbs.	465 lbs.	566 lbs.
Weight of ashes left	15 lbs.	14 lbs.	13 lbs.
Per centage of combustible matter in ashes	22·8	16·7	20·0
Weight of cinder left	8 lbs.	12 lbs.	8 lbs.
Per centage of combustible matter in cinder	70·0	66·6	62·9

	October 11, 1st day.	October 12, 2nd day.	October 13, 3rd day.
Weight of clinker in cinder	10 lbs.	6 lbs.	9 lbs.
Average weight of soot in flues	·33 lb.	·33 lb.	·33 lb.
Per centage of combustible matter in soot	57·3	..	..
Weight of water evaporated	3910 lbs.	2660 lbs.	3560 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·38 lbs.	6·66 lbs.	7·10 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·15 lbs.	11·62 lbs.	14·75 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·278	..	..
Mean weight of cubic foot of coal	48·41 lbs.	..	..
Economic weight, or space occupied by 1 ton	46·28 ft.	..	..
Cohesive power of coal	76·5	..	..

Note.—Final temperature on fourth morning, 188°.

Hoyland and Elsecar Co.'s Hard Coal.

I HEREBY certify that the four boxes marked H. and E. C. C°., also T. S. H. H., contain a fair sample of the Hoyland and Elsecar Co.'s coals, which were mined specially for the service of the "Admiralty Coals Investigation."—TIMOTHY SMITH, *Manager.*

This coal is extracted from the Barnsley or Three Yard seam, and is worked at Hoyland Nether, under the name of the Hoyland and Elsecar Co.'s coal. The present pits are respectively 130 and 132 yards in depth. The seam has a dip of 1 in 14 N.E. and varies from 7 feet 6 inches to 8 feet in thickness. It is overlaid by thick strata of "strong blue band," with fire-clay underneath.

This coal is described as being "very hard, durable, and excellent for steam purposes." The mine is worked in banks or stalls to the rise of the seam, 30 yards wide, with 30 yards of pillars left for the purpose of working back to the level. The principal market is Hull, from whence the coal is exported to the various ports on the eastern coast of England. The present current price at the shipping staith at Elsecar, on the Dearne and Dove canal, is 5*s.* 9*d.* per ton.

The sample of the coal which came into our hands very much resembled silicified wood in structure, consisting of broad layers of a brownish colour, with alternate bands of a bright jet-like substance. Under the boiler it was observed to light easily and burn freely, leaving large quantities of white ash, which impeded the action of the draught: much smoke was evolved during the experiments, especially when fresh coals were thrown on the fire.

The best results were obtained when a moderately quick draught was employed.

	October 15, 1st day.	October 16, 2nd day.	October 17, 3rd day.
Fire lighted	9 h. 45 m.	7 h. 25 m.	9 h. 50 m.
Steam up	10 h. 15 m.	7 h. 50 m.	10 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	188°	196°	206°
Temperature of water in tanks	50°	52°	54°
Barometer	30·03 in.	30·07 in.	30·25 in.
Extremes of external thermometer	39°—51°	43°—58°	54°—62°
Extremes of internal thermometer	52°—57°	57°—62°	58°—65°
Dewpoint	47°	48°	51°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	488 lbs.	402 lbs.	401 lbs.
Weight of ashes left	13 lbs.	19 lbs.	21 lbs.
Per centage of combustible matter in ashes	33·0	23·0	31·0
Weight of cinder left	19 lbs.	21 lbs.	26 lbs.
Per centage of combustible matter in cinder	66·6	59·6	60·7
Weight of clinker in cinder	1 lb.	..	..
Average weight of soot in flues	0·66 lb.	0·66 lb.	0·66 lb.
Per centage of combustible matter in soot	81·8	..	..
Weight of water evaporated	3540 lbs.	2670 lbs.	2740 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·49 lbs.	7·83 lbs.	7·90 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·20 lbs.	10·05 lbs.	10·02 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·317	..	..
Mean weight of cubic foot of coal	48·24 lbs.	..	..
Economic weight or space occupied by 1 ton	46·47 ft.	..	..
Cohesive power of coal	82·5	..	..

Note.—Final temperature on fourth morning, 208°.

Aberaman Merthyr Coal.

I HEREBY certify that the four casks marked $\frac{A}{M}$ Nos. 1, 2, 3, 4, contain a fair sample of the Aberaman Merthyr coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JAMES A. WISE, *Agent*.

This coal is worked from the Aberaman 4 feet vein. The pit (81 yards in depth) is situated on the Aberaman estate on the west side of Aberaman Valley, Glamorganshire. The seam, which is regular, and 6 feet in thickness, has an inclination of 3 inches in the yard towards the south, and is worked by stalls and pillars, the subjacent and overlying strata being composed of "strong shale." The mine is situated at a distance of about 22 miles from Cardiff, from whence the coals are shipped to all the principal ports in the world where steam coals are employed. The current price is 10*s*. per ton.

The specimen examined was brilliant, and granular in its structure, but exhibited little of the radiated appearance so frequently observed in other coals fron this district. Small quantities of white shale were perceived, but it contained little or no iron pyrites; although layers of a substance resembling mineralized charcoal were very abundant.

This coal when once lighted was found to make a good clear fire, and with a quick draught blows off steam rapidly. The clinker produced was not in large quantities, and did not adhere to the bars, but the amount of ash was greater than from many varieties of the South Wales coals. Little smoke was evolved during the experiments.

	October 18, 1st day.	October 19, 2nd day.	October 20, 3rd day.
Fire lighted	9 h. 15 m.	9 h. 15 m.	6 h. 45 m.
Steam up	9 h. 30 m.	9 h. 45 m.	7 h. 10 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	208°	210°
Temperature of water in tanks	58°	58°	60°
Barometer	30·05 in.	30·07 in.	30·03 in.
Extremes of external thermometer	50°—65°	55°—65°	43°—63°
Extremes of internal thermometer	64°—69°	66°—70°	56°—68°
Dewpoint	49°	48°	50°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	486 lbs.	294 lbs.	425 lbs.
Weight of ashes left	8 lbs.	17 lbs.	12 lbs.
Per centage of combustible matter in ashes	67·0	69·3	63·4
Weight of cinder left	12 lbs.	18 lbs.	15 lbs.
Per centage of combustible matter in cinder	82·0	85·5	76·1
Weight of clinker in cinder	4 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4250 lbs.	2330 lbs.	3630 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	10·07 lbs.	9·09 lbs.	9·43 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·15 lbs.	7·35 lbs.	10·62 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·298	..	..
Mean weight of cubic foot of coal	51·41 lbs.	..	..
Economic weight or space occupied by 1 ton	43·57 ft.	..	..
Cohesive power of coal	74·0	..	..

Note.—Final temperature on fourth morning, 185°.

Earl Fitzwilliam's Elsecar Coal.

I HEREBY certify that the four boxes marked E. contain a fair sample of the Elsecar Colliery hard coals, which were mined specially for the service of the "Admiralty Coals Investigation."—BENJAMIN BIRAM, *Agent for Earl Fitzwilliam.*

This coal is the produce of the Barnsley or Elsecar seam, and was raised from a pit near Fingles Bridge, in the township of Brampton Breston, at a depth of 154 yards from the surface. The vein has a dip of 1 in 12 towards the north-east, and is usually about 9 feet in thickness. The overlying stratum is "stone bind," and the subjacent, fire-clay. The coal is worked in faces of 40 or 50 yards in length. The principal market is Hull, which is about 80 miles from the colliery, but large quantities are consumed by iron-works in the immediate neighbourhood of the mine. The present current price is 5*s*. 9*d*. per ton of 21 cwt.

This very much resembles the Hoyland and Elsecar Co.'s coal, but is brighter and contains more iron pyrites. During the experiments it was found to light easily, burn freely, and get up steam rapidly; considerable quantities of ash were, however, produced, and unless the fire was frequently cleared, the draught became choked, and the clearness of the fire impaired.

	October 22, 1st day.	October 23, 2nd day.	October 24, 3rd day.
Fire lighted	10 h. 25 m.	9 h. 30 m.	9 h. 25 m.
Steam up	10 h. 55 m.	9 h. 45 m.	9 h. 50 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	185°	208°	202°
Temperature of water in tanks	56°	58°	60°
Barometer	30·15 in.	30·21 in.	30·33 in.
Extremes of external thermometer	54°—62°	49°—61°	53°—63°
Extremes of internal thermometer	60°—66°	61°—67°	64°—67°
Dewpoint	55°	54°	54°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	533 lbs.	386 lbs.	433 lbs.
Weight of ashes left	9 lbs.	11 lbs.	13 lbs.
Per centage of combustible matter in ashes	19·8	13·7	20·1
Weight of cinder left	11 lbs.	17 lbs.	14 lbs.
Per centage of combustible matter in cinder	79·8	80·7	80·0
Weight of clinker in cinder	2 lbs.	1 lb.	1 lb.
Average weight of soot in flues	·5 lb.	·5 lb.	·5 lb.
Per centage of combustible matter in soot	78·5	..	..
Weight of water evaporated	3900 lbs.	2900 lbs.	3105 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·71 lbs.	8·51 lbs.	8·34 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·32 lbs.	9·65 lbs.	10·82 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·296	..	..
Mean weight of cubic foot of coal	47·24 lbs.	..	..
Economic weight or space occupied by 1 ton	47·45 ft.	..	..
Cohesive power of coal	77·0	..	..

Note.—Final temperature on fourth morning, 209°.

Earl Fitzwilliam's Park Gate Coal.

I HEREBY certify that the four boxes marked P. contain a fair sample of the Park Gate Colliery Hard Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—BENJAMIN BIRAM, *Agent for Earl Fitzwilliam.*

This coal like the foregoing is extracted from the Elsecar or Barnsley seam. The pit is situated on the north side of the village of Rawmarsh, and is 120 yards in depth. The vein is generally about 7 feet 6 inches in thickness, but varies from 6 feet 8 inches to 8 feet, and has a dip of 1 in 10 to the north of east. The subjacent strata are composed of "spavin," or fire-clay, and the overlying of sandstone.

This mine is worked in faces of about 45 yards in length. The principal market for the coal is Hull, but a large proportion is consumed in the neighbourhood of the mine for the manufacture of iron.

In appearance this coal closely resembles the Elsecar last described, but under the boiler was found to leave more ash and not any clinker. In other respects its behaviour was precisely similar.

	October 25, 1st day.	October 26, 2nd day.	October 29, 3rd day.
Fire lighted	9 h. 20 m.	9 h. 20 m.	10 h. 45 m.
Steam up	9 h. 45 m.	9 h. 40 m.	11 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	209°	208°	184°
Temperature of water in tanks	58°	58°	56°
Barometer	30·07 in.	29·93 in.	30·01 in.
Extremes of external thermometer	56°—62°	50°—60°	42°—65°
Extremes of internal thermometer	64°—68°	62°—68°	58°—67°
Dewpoint	53°	50°	48°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	496 lbs.	337 lbs.	528 lbs.
Weight of ashes left	15 lbs.	14 lbs.	19 lbs.
Per centage of combustible matter in ashes	16·3	24·0	29·0
Weight of cinder left	16 lbs.	26 lbs.	12 lbs.
Per centage of combustible matter in cinder	72·2	72·3	81·4
Weight of clinker in cinder	None	..	..
Average weight of soot in flues	·5 lb.	·5 lb.	·5 lb.
Per centage of combustible matter in soot	88·0	..	..
Weight of water evaporated	3490 lbs.	2380 lbs.	3580 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·08 lbs.	7·64 lbs.	8·04 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·40 lbs.	8·42 lbs.	13·20 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·311	..	..
Mean weight of cubic foot of coal	46·99 lbs.	..	..
Economic weight or space occupied by 1 ton	47·65 ft.	..	..
Cohesive power of coal	78·0	..	..

Note.—Final temperature on fourth morning, 204°.

West Hartley Main Coal.

I HEREBY certify that the four boxes marked W. H. contain a fair sample of the West Hartley Main Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—EDWARD POTTER, *Proprietor and Agent.*

The Cramlington colliery, from which these coals are raised, is worked on the low main seam, 10 miles north-east of Newcastle. This vein is regular, and about 6 feet in thickness, having an inclination of 1 in 30 towards the south-east. The subjacent and overlying strata are composed of shale and freestone. The mine is worked by the bond and pillar system, and its present depth from the surface is 90 fathoms. The current price of the coal, which is chiefly used for steam purposes, is from 7*s.* to 7*s.* 6*d.* per ton.

The specimen which came into our hands was of a full black colour, with a resinous and frequently conchoidal fracture, although it more frequently exhibited a tendency to split into cubes.

When tried under the experimental boiler these coals were found to light easily, blowing off the steam rapidly, and leaving little ash or clinker on the grate, but, like others from the north of England, much smoke was evolved during their combustion.

	October 30, 1st day.	October 31, 2nd day.	November 1, 3rd day.
Fire lighted	10 h. 0 m.	9 h. 30 m.	9 h. 20 m.
Steam up	10 h. 20 m.	9h. 50 m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	204°	208°	211°
Temperature of water in tanks	56°	54°	54°
Barometer	29·95 in.	29·77 in.	29·80 in.
Extremes of external thermometer	46°—58°	43°—54°	44°—55°
Extremes of internal thermometer	57°—65°	58°—62°	58°—62°
Dewpoint	48°	47°	47°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	612 lbs.	442 lbs.	535 lbs.
Weight of ashes left	9 lbs.	11 lbs.	10 lbs.
Per centage of combustible matter in ashes	44·6	45·7	44·7
Weight of cinder left	11 lbs.	13 lbs.	11 lbs.
Per centage of combustible matter in cinder	80·0	72·9	76·8
Weight of clinker in cinder	1 lb.	none	1 lb.
Average weight of soot in flues	1 lb.	1 lb.	1 lb.
Per centage of combustible matter in soot	73·3	..	..
Weight of water evaporated	4480 lbs.	2880 lbs.	3620 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·44 lbs.	7·56 lbs.	7·60 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·30 lbs.	11·05 lbs.	13·37 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·264	..	..
Mean weight of cubic foot of coal	49·00 lbs.	..	..
Economic weight or space occupied by 1 ton	45·80 ft.	..	..
Cohesive power of coal	79·0	..	..

Note.—Final temperature on fourth morning, 194°.

Butterly Co.'s Portland Hard Coal.

I HEREBY certify that the coals sent to Putney College, and marked B. P., are a fair sample of the Butterly Company's Portland Hard Coals, which were mined specially for the service of the "Admiralty Coals Investigation." —WILLIAM BEAN, *Agent.*

The pit by which this coal was extracted is situated at Kirkby, in Ashfield, Notts, and is sunk on what is called in Derbyshire and Nottinghamshire the Upper Hard coal seam. The mine is worked by the "long wall" system to a depth 180 yards from the surface. The thickness of the vein is irregular, varying from 3 feet 6 inches to 5 feet. There is also considerable variation both in its direction and inclination. The subjacent and overlying strata are composed of indurated clay. This coal is transported by railway to the counties of Lincoln, Rutland, and Northampton. Its present price is 6*s.* 9*d.* per ton upon the Erewash Valley Railway at Codnor Park.

The specimen sent for the purposes of the Investigation was excessively hard, and contained much mineralized charcoal in the jointings, with thin strata of bright coal occasionally intervening.

We remarked that it lighted easily, and when thrown on the fire made a crackling noise. It burned freely and left a whitish-coloured ash, which, however, soon choked the draught, if not frequently removed by the rake. The clinker, though rather considerable in quantity, did not stick to the bars. Much smoke was evolved, especially on stoking or charging the fire.

	November 5, 1st day.	November 6, 2nd day.	November 7, 3rd day.
Fire lighted	9 h. 25 m.	9 h. 40 m.	9 h. 15 m.
Steam up	9 h. 55 m.	10 h. 0m.	9 h. 30 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	184°	204°	208°.
Temperature of water in tanks	52°	52°	52°.
Barometer	30·12 in.	29·74 in.	30·15 in.
Extremes of external thermometer	39°—52°	36°—54°	54°—58°
Extremes of internal thermometer	53°—61°	53°—61°	60°—67°
Dewpoint	45°	45°	. 49°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	639 lbs.	491 lbs.	601 lbs.
Weight of ashes left	15 lbs.	12 lbs.	13 lbs.
Per centage of combustible matter in ashes	21·1	22·7	23·7
Weight of cinder left	11 lbs.	8 lbs.	8 lbs.
Per centage of combustible matter in cinder	66·9	64·0	57·5
Weight of clinker in cinder	3 lbs.	2 lbs.	3 lbs.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	70·7	..	..
Weight of water evaporated	4190 lbs.	3400 lbs.	4100 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·78 lbs.	8·06 lbs.	7·92 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·97 lbs.	12·27 lbs.	15·02 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·301	..	..
Mean weight of cubic foot of coal	47·16 lbs.	..	..
Economic weight or space occupied by 1 ton	47·55 ft.	..	..
Cohesive power of coal	89·0	..	..

Note.—Final temperature on fourth morning, 210°.

Butterly Co.'s Langley Hard Coal.

I HEREBY certify that the coals sent to Putney College, and marked B. L., are a fair sample of the Butterly Company's Langley Hard Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM BEAN, *Agent.*

This coal is extracted from the lower hard coal seam of Derbyshire and Notts, at Heaner, in the former county. The seam is 3 feet in thickness, and varies in its inclination from 1 in 2 to 1 in 8. The direction of the dip also varies from south to west. The subjacent and overlying strata are composed of indurated clay and clay-slate.

The coal is raised at a depth of 70 yards from the surface, where the working is effected by the same system as in the Portland colliery. This, like the foregoing coal, is transported by railway and canal to the neighbouring counties of Nottingham, Lincoln, Leicester, Rutland, and Northampton, which are the principal markets. At Heaner, on the Erewash Valley railway, its present current price is 6*s.* per ton.

In appearance this coal closely resembles that last described, but contained more iron pyrites. Under the boiler it also burned similarly to the foregoing, with the exception of its leaving more ash, which rendered the use of the rake more frequently necessary than in the case of the Portland coals.

	November 8, 1st day.	November 9, 2nd day.	November 10, 3rd day.
Fire lighted	9 h. 30 m.	9 h. 15 m.	9 h. 40 m.
Steam up	9 h. 45 m.	9 h. 30 m.	10 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	210°	211°	206 °
Temperature of water in tanks	54°	56°	56°
Barometer	30·43 in.	30·40 in.	30·36 in.
Extremes of external thermometer	54°—60°	50°—60°	42°—59°
Extremes of internal thermometer	65°—67°	65°—68°	57°—65°
Dewpoint	55°	51°	50°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	574 lbs.	382 lbs.	386 lbs.
Weight of ashes left	21 lbs.	15 lbs.	14 lbs.
Per centage of combustible matter in ashes	17·1	26·5	27·2
Weight of cinder left	10 lbs.	10 lbs.	9 lbs.
Per centage of combustible matter in cinder	57·8	57·9	57·0
Weight of clinker in cinder	3 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	·6 lb.	·6 lb.	·6 lb.
Per centage of combustible matter in soot	51·0	..	..
Weight of water evaporated	3760 lbs.	2700 lbs.	2710 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·64 lbs.	8·03 lbs.	7·74 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·35 lbs.	9·55 lbs.	11·03 lbs.
Duration of experiment	8 hrs.	8 hrs.	7 hrs.

	November 8, 1st day.	November 9, 2nd day.	November 10, 3rd day.
Specific gravity of coal	1·264	..	..
Mean weight of cubic foot of coal	47·83 lbs.	..	..
Economic weight, or space occupied by 1 ton	46·86 ft.	..	..
Cohesive power of coal	84·5	..	..

Note.—Final temperature on fourth morning, 186°.

Brymbo Main Coal.

I HEREBY certify that the five casks marked B. M. P. contain a fair sample of the Brymbo Main Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM WALTERS, *Agent.*

This coal is raised from what is called the "main vein" at Brymbo iron-works. The seam is regular and 6 feet in thickness, with a rise of 1 in 6 towards the west. The overlying and subjacent strata consist of shale, coal, and freestone.

The coal is described as "strong and large," and is worked by pillars at a depth of about 180 yards from the surface. The mine is about 12 miles distant from the shipping port of Saltney, on the Dee, and 27 miles from Birkenhead, on the Mersey, at the former of which places the coals are put free on board for 6*s.* 8*d.* per ton, and at the latter 7*s.* 6*d.* per ton is charged.

The sample sent up for experiment was very brilliant, and when broken exhibited a distinctly cubical fracture, with large quantities of iron pyrites and reddish white shale between the jointings. During our experiments it was observed to light very easily, and make a good clear fire which required little stoking. It also generated steam quickly, but evolved much black smoke. The clinker left was not considerable in amount, and did not adhere to the bars.

	November 12, 1st day.	November 13, 2nd day.	November 14, 3rd day.
Fire lighted	9 h. 40 m.	9 h. 35 m.	9 h. 5 m.
Steam up	10 h. 0 m.	9 h. 45 m.	9 h. 25 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	186°	209°	200°
Temperature of water in tanks	56°	54°	52°
Barometer	30·11 in.	30·01 in.	29·80 in.
Extremes of external thermometer	44°—55°	48°—57°	46°—51°
Extremes of internal thermometer	57°—65°	58°—62°	59°—62°
Dewpoint	..	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	565 lbs.	412 lbs.	488 lbs.
Weight of ashes left	13 lbs.	11 lbs.	11 lbs.
Per centage of combustible matter in ashes	21·0	26·2	22·5
Weight of cinder left	11 lbs.	9 lbs.	12 lbs.
Per centage of combustible matter in cinder	71·0	75·4	80·9
Weight of clinker in cinder	3 lbs.	1 lb.	3 lbs.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	46·6	..	..
Weight of water evaporated	4030 lbs.	3100 lbs.	3330 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·49 lbs.	8·52 lbs.	8·07 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·12 lbs.	10·30 lbs.	12·20 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·300	..	..
Mean weight of cubic foot of coal	47·08 lbs.	..	..
Economic weight, or space occupied by 1 ton	47·65 ft.	..	..
Cohesive power of coal	..	..	..

Note.—Final temperature on fourth morning, 212°.

Arley or Orrell Coal.

I HEREBY certify that the three casks marked (A) 1 to 3, contain a fair sample of the Arley or Orrell Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM LANCASTER, *Managing Director of the Ince Hall Coal and Cannel Company, Wigan.*

The Ince Hall Arley mine is situated in the township of Ince, in the parish of Wigan, 22 miles from the port of Liverpool, and 16 from Preston. The vein, which is regular, and 4 feet 3 inches in thickness, has an inclination of 1 in 7, 10° north of east. The mine is worked by pillars and stalls, at a depth of 414 yards from the surface. The seam lies on a hard floor, and the roof consists of blue shale.

This coal is said to be principally used for domestic purposes, and is described as being

"highly bituminous, and leaving little ash." The chief markets are Liverpool, Manchester, Preston, and Fleetwood. The present current price for screened coal is, at the pit's mouth, 7*s.* per ton; but when put free on board at Liverpool, 9*s.* 6*d.* per ton is charged. The specimen experimented on was brilliant and slightly granular in its appearance, with the lines of stratification less distinctly defined than in other coals from the same district; it also contained thin layers of white shale between the planes of cleavage, together with numerous spots of iron pyrites.

It was remarked that this coal lighted easily, caking slightly on the grate, and giving off much smoke. The clinker formed, though inconsiderable in quantity, adhered so tenaciously to the bars as to render its removal very difficult.

——	November 16, 1st day.	November 17, 2nd day.	November 19, 3rd day.
Fire lighted	10 h. 0 m.	9 h. 45 m.	9 h. 45 m.
Steam up	10 h. 10 m.	10 h. 25 m.	10 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	212°	190°	206°
Temperature of water in tanks	52°	48°	50°
Barometer	29·79 in.	30·27 in.	30·35 in.
Extremes of external thermometer	37°—53°	32°—47°	33°—53°
Extremes of internal thermometer	53°—60°	50°—57°	50°—58°
Dewpoint	..	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	572 lbs.	410 lbs.	480 lbs.
Weight of ashes left	15 lbs.	14 lbs.	12 lbs.
Per centage of combustible matter in ashes	19·1	22·0	27·2
Weight of cinder left	8 lbs.	12 lbs.	13 lbs.
Per centage of combustible matter in cinder	76·0	63·6	71·6
Weight of clinker in cinder	3 lbs.	2 lbs.	2 lbs.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	63·1	..	..
Weight of water evaporated	4760 lbs.	3155 lbs.	3780 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·39 lbs.	9·17 lbs.	8·85 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·30 lbs.	10·25 lbs.	12·00 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·272	..	..
Mean weight of cubic foot of coal	47·66 lbs.	..	..
Economic weight, or space occupied by 1 ton	47·05 ft.	..	..
Cohesive power of coal	73·5	..	..

Note.—Final temperature on fourth morning, 185°.

Coleshill Co.'s Bagilt Main Coal.

I HEREBY certify that the seven casks marked B. M. S., Nos. 1 to 7, contain a fair sample of the Coleshill Coal Company's Bagilt Main Seam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—WILLIAM MAXWELL, *Agent.*

The Bagilt Main Seam Colliery is situated in the township of Bagilt, in the parish of Holywell, bordering on the Dee, from which river it is distant about one mile. The coal is worked at a depth of 100 yards from the surface, either in stalls or by what is called "long work" as circumstances may admit. The present operations are carried on in stalls 6 yards wide.

The vein is 5 feet in thickness, and generally regular, having a dip of about 1 in 5 towards the east. The subjacent and overlying strata are rock, shale, and fire-clay.

The description given of this coal by the agent is that "it burns freely, contains a great quantity of bitumen, and leaves a white ash." The principal markets are Liverpool, Ireland, the Welsh coast, and the local smelting establishments. The present current price averages about 7*s.* per ton.

The specimen tried at Putney had a rather brilliant appearance, with the lines of stratification indistinctly developed, and contained both iron pyrites and the white shaly matter so often mentioned in this Report. Under the boiler it was observed to light easily, burn freely, and blow off much steam; it also evolved large quantities of smoke. The amount of clinker left was small; it did not stick to the bars.

——	November 20, 1st day.	November 21, 2nd day.	November 22, 3rd day.
Fire lighted	10 h. 30 m.	9 h. 45 m.	10 h. 0 m.
Steam up	11 h. 15 m.	10 h. 0 m.	10 h. 25 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	185°	211°	196°
Temperature of water in tanks	44°	46°	48°
Barometer	30·12 in.	30·23 in.	30·01 in.
Extremes of external thermometer	41°—53°	°46—50°	40°—51°

	November 20, 1st day.	November 21, 2nd day.	November 22, 3rd day.
Extremes of internal thermometer	56°—60°	55°—62°	54°—60°
Dewpoint	..	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	574 lbs.	481 lbs.	498 lbs.
Weight of ashes left	8 lbs.	10 lbs.	7 lbs.
Per centage of combustible matter in ashes	25·0	23·2	19·8
Weight of cinder left	10 lbs.	13 lbs.	8 lbs.
Per centage of combustible matter in cinder	88·8	82·0	80·5
Weight of clinker in cinder	2 lbs.	1 lb.	1 lb.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	66·6	..	..
Weight of water evaporated	3820 lbs.	3580 lbs.	3670 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·05 lbs.	8·44 lbs.	8·50 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·35 lbs.	12·02 lbs.	12·45 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·269	..	..
Mean weight of cubic foot of coal	49·63 lbs.	..	..
Economic weight, or space occupied by 1 ton	45·16 ft.	..	..
Cohesive power of coal	79·0	..	..

Note.—Final temperature on fourth morning, 192°.

Kilmarnock Skerrington.

I HEREBY certify that the four casks marked K. S. S., 1 to 4, contain a fair sample of the Kilmarnock Skerrington Splint Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—JOHN COLVIL, *Agent, Troon;* ALLAN GILMOUR *and* Co., *Proprietors, Kilmarnock.*

This colliery is situated in the lands of Skerrington and Herlford, near Kilmarnock, in the county of Ayr. The vein, which varies from 10 to 11 feet in thickness, is at present worked at a depth of 60 fathoms from the surface, where it has an inclination of 1 in 12 towards the south. The subjacent and overlying strata consist of shale, sandstone, and fire-clay; and the coals, which have been described as "clear and quick-burning," are extracted by the stoop and room method. Troon and Irvine (from both which towns the mine is distant about 12 miles) are the principal shipping ports, where the coals are delivered free on board at 6*s.* per ton.

This coal, having been but recently discovered, has not as yet been much in the market for steam purposes, although it has been employed with success by the Ayrshire Railway Company in their locomotives, and is generally approved of for steam vessels.

The sample which came into our hands was bright, but contained considerable quantities both of white shale and iron pyrites. Some portions of the specimen sent us resembled cannel, having a resinous black lustre and conchoidal fracture; but the generality of the fragments presented the usual characteristics of splint coal.

During the experiments this coal was found to light easily and burn freely, giving off much smoke, and leaving a considerable amount of ash, and but little clinker. In order to consume the smoke, air was on the first and second days admitted behind the fire bridge; but on the third day this was not done, as it was considered advisable to make experiments under varying circumstances.

	March 26, 1st day.	March 27, 2nd day.	March 28, 3rd day.
Fire lighted	9 h. 25 m.	9 h. 40 m.	8 h. 55 m.
Steam up	9 h. 45 m.	9 h. 55 m.	9 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	192°	206°	208°
Temperature of water in tanks	45°	45°	45°
Barometer	29·82 in.	30·06 in.	..
Extremes of external thermometer	28°—41°	25°—47°	27°—47°
Extremes of internal thermometer	40°—46°	45°—54°	46°—56°
Dewpoint	42°	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	731 lbs.	441 lbs.	552 lbs.
Weight of ashes left	14 lbs.	14 lbs.	10 lbs.
Per centage of combustible matter in ashes	46·4	53·0	64·5
Weight of cinder left	6 lbs.	5 lbs.	5 lbs.
Per centage of combustible matter in cinder	84·4	94·9	95·0
Weight of clinker in cinder	3 lbs.	1 lb.	1 lb.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	56·5	..	..
Weight of water evaporated	4790 lbs.	2720 lbs.	3790 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·77 lbs.	7·24 lbs.	7·97 lbs.
Weight of coals per hour for 1 square foot of grate surface	18·27 lbs.	11·02 lbs.	13·80 lbs.

is worked by the stall and pillar system. The subjacent strata are composed of rock, and the overlying of fire-clay.

The mine is 250 yards in depth, and the coals are described by the proprietor as "free burning and well suited for steam purposes." He also adds that the present openings are equal to produce 500 tons per day, and command an area of about 3000 acres of coal. The coals are conveyed by railway to Newport, a distance of about 9 miles, and are from thence exported to the various home and foreign markets. They have also been employed both by the English and French governments for the purposes of their steam navies, and are highly recommended for steam purposes generally.

In appearance it resembles the other specimens coming from the same district, having a bright cubical fracture, and exhibiting none of the white shale met with in the varieties from the north of England: it is however rather friable, and contains much iron pyrites and mineralized charcoal.

Under the boiler it was found to light easily; but unless much attention was paid to the stoking, it caked on the fire and burnt slowly, giving off much smoke. In practice we found that the best fire could be obtained by keeping a layer of coals on the bars from 7 to 8 inches in thickness, and pushing them when heated from the dead-plate on to the fire, so as to supply the place of those consumed. By this means a good fire, tolerably free from smoke, was obtained; but the weight of ash remaining was large, and the amount of clinker rather considerable. The clinker adhered firmly to the bars, and could not be separated from them without difficulty. Large quantities of clinker were also weighed with the ash, in pieces too small to separate in the ordinary way.

	April 4, 1st day.	April 5, 2nd day.	April 6, 3rd day.
Fire lighted	9 h. 55 m.	11 h. 40 m.	7 h. 55 m.
Steam up	10 h. 0 m.	12 h. 0 m.	8 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	212°	200°	208°
Temperature of water in tanks	53°	54°	54°
Barometer	29·34 in.	30·00 in.	29·82 in.
Extremes of external thermometer	47°—60°	42°—58°	48°—63°
Extremes of internal thermometer	61°—64°	59°—64°	58°—65°
Dewpoint	..	..	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	500 lbs.	410 lbs.	493 lbs.
Weight of ashes left	10 lbs.	10 lbs.	13 lbs.
Per centage of combustible matter in ashes	19·5	42·3	26·8
Weight of cinder left	6 lbs.	6 lbs.	5 lbs.
Per centage of combustible matter in cinder	71·5	91·5	87·5
Weight of clinker in cinder	8 lbs.	4 lbs.	5 lbs.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	65·3	..	..
Weight of water evaporated	3970 lbs.	3430 lbs.	4120 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·19 lbs.	9·80 lbs.	9·43 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·50 lbs.	10·25 lbs.	12·32 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·334	..	..
Mean weight of cubic foot of coal	50·33 lbs.	..	..
Economic weight or space occupied by 1 ton	44·53 ft.	..	..
Cohesive power of coal	54·5	..	..

Note.—Final temperature on second morning, 211°.
Final temperature on fourth morning, 190°.

Aberaman Merthyr.

A specimen of this coal was tested by the officers of the Investigation on the 18th, 19th, and 20th of October, 1849; but on the 5th of April, 1850, another sample arrived at Putney, accompanied with the following letter:—

113, Fenchurch-street, April 5th, 1850.

Sir,—By permission of Sir Henry De la Beche, C.B., we have forwarded three casks, marked A. M. C., to your address, to be tested for the "Admiralty Coals Investigation."

The reason we have forwarded a second sample of the "Aberaman Merthyr" Steam Coals is, that we have recently learned that the samples previously forwarded were not (by an error of our workmen) those that we sell for steam purposes. The certificate we sent you on October 11th is the one that should have accompanied such a sample as we now send.

We are, Sir, your obedient servants,
Maltman, Shaw, & Co.

J. Arthur Phillips, Esq.,
College for Civil Engineers, Putney.

	April 8, 1st day.	April 9, 2nd day.	April 10, 3rd day.
Fire lighted	9 h. 45 m.	9 h. 0 m.	8 h. 40 m.
Steam up	10 h. 10 m.	9 h. 15 m.	9 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	190°	206°	198°
Temperature of water in tanks	56°	53°	53°
Barometer	29·44 in.	29·48 in.	29·53 in.
Extremes of external thermometer	47°—58°	43°—56°	44°—58°
Extremes of internal thermometer	60°—64°	60°—63°	60°—64°
Dewpoint	..	47°	..
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	532 lbs.	338 lbs.	468 lbs.
Weight of ashes left	14 lbs.	15 lbs.	13 lbs.
Per centage of combustible matter in ashes	69·4	66·9	50·0
Weight of cinder left	11 lbs.	16 lbs.	10 lbs.
Per centage of combustible matter in cinder	82·8	91·4	91·1
Weight of clinker in cinder	3 lbs.	2 lbs.	3 lbs.
Average weight of soot in flues	None.	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4675 lbs.	3260 lbs.	4370 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	10·35 lbs.	10·99 lbs.	10·93 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·30 lbs.	8·45 lbs.	11·70 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·313	..	..
Mean weight of cubic foot of coal	48·99 lbs.	..	..
Economic weight or space occupied by 1 ton	45·80 ft.	..	..
Cohesive power of coal	..	..	..

Note.—Final temperature on fourth morning, 206°.

Loscoe Coals.

I HEREBY certify that the three casks marked Loscoe H. contain a fair sample of the Loscoe Hard Coals; and that the four casks marked Loscoe S. contain a fair sample of the Loscoe Soft Coals, and that both these specimens were mined specially for the service of the "Admiralty Coals Investigation."—W. M. LIGHTFOOT.

The two seams from which these coals are extracted are situated in Derbyshire, at Loscoe, on the borders of Nottinghamshire, 10 miles from Derby, and 12 from Nottingham. The hard-coal seam is 2 feet 8 inches in thickness, and is worked at a depth of 130 yards from the surface, whilst the soft-coal seam is thicker by about a foot, and is mined at a depth of 112 yards. Both seams are tolerably regular, and have an inclination of 1 in 7, about 10° to the west of north. The coals are extracted from each of these veins by what is called "long work;" but they differ very materially in their qualities, as the "soft" is considered a good household and gas coal, whilst the "hard" is chiefly recommended for steam purposes. The subjacent and overlying strata are composed of iron-stone, bind, shale, and rock of various kinds. These coals sell at the pit's mouth at from 5*s.* to 7*s.* per ton, and are chiefly consumed in the Midland counties, although a certain portion of the produce of the mine is annually sent to London.

The Loscoe soft coal is bright, with a splinty fracture, and contains much white shale and iron pyrites.

The hard variety is duller in its general appearance than the foregoing, but contains thin layers of very bright coal, together with iron pyrites and white shale.

Under the boiler the soft coal lighted readily and blew off steam briskly, but with the evolution of much smoke, especially when fresh fuel was thrown on the grate. With great attention on the part of the stoker, this could to a certain extent be prevented; but towards the close of the experiments the grate became choked with a hard dark-coloured clinker, very difficult to remove, which impeded the draught and caused considerable annoyance. The ash left was of a greyish colour, but not very considerable in quantity.

The hard coal was found not to burn so freely as the soft; but after a time the grate became coated with clinker, which required frequent removal in order to keep up the fire, from which much smoke was evolved, particularly on feeding or stoking.

	April 11, 1st day. L. S.	April 12, 2nd day. L. S.	April 13, 3rd day. L. H.
Fire lighted	9 h. 30m.	9h. 10m.	8 h. 40 m.
Steam up	9 h. 50m.	9h. 30 m.	8 h. 55 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	206°	209°	210°
Temperature of water in tanks	54°	56°	54°
Barometer	29·54 in.	29·82 in.	29·97 in.

	April 11, 1st day. L. S.	April 12, 2nd day. L. S.	April 13, 3rd day. L. H.
Extremes of external thermometer	47°—61°	46°—59°	46°—57°
Extremes of internal thermometer	62°—68°	60°—66°	59°—64°
Dewpoint	53°	53·5°	51°
Area of damper open	112 in.	84 in.	84 in.
Weight of coals consumed	737 lbs.	596 lbs.	525 lbs.
Weight of ashes left	7 lbs.	7 lbs.	12 lbs.
Per centage of combustible matter in ashes	63·3	28·7	32·6
Weight of cinder left	6 lbs.	9 lbs.	10 lbs.
Per centage of combustible matter in cinder	54·5	79·7	62·9
Weight of clinker in cinder	2 lbs.	3 lbs.	2 lbs.
Average weight of soot in flues	·4 lb.	·4 lb.	·4 lb.
Per centage of combustible matter in soot	90·2	..	..
Weight of water evaporated	4670 lbs.	3315 lbs.	3020 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·36 lbs.	6·41 lbs.	4·32 lbs.
Weight of coals per hour for 1 square foot of grate surface	21·05 lbs.	17·02 lbs.	15·00 lbs.
Duration of experiment	7 hrs.	7 hrs.	7 hrs.
Specific gravity of coal	1·285	..	1·276
Mean weight of cubic foot of coal	44·85 lbs.	..	45·91
Economic weight or space occupied by 1 ton	50 ft.	..	48·80 ft.
Cohesive power of coal	62·0	..	86·0

Note.—Final temperature on fourth morning, 184°.

Caldwell and Thomson's Rushy Park.

I HEREBY certify that the four casks marked No. 1, 2, 3, and 4 contain a fair sample of the Rushy Park Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CALDWELL and THOMSON *per* E. FIDLER, Jun.

The mine from which this coal is extracted is situated at Rushy Park, in the township of Windle, within half a mile of the town of St. Helen's, Lancashire.

This vein is 4 feet 6 inches in thickness, very regular, and has a dip of 2 in 7 towards the south. The overlying and subjacent strata consist of "shale and white stone," and the mine, which is 170 yards in depth, is worked by walls and bays. The coal is described as "igniting easily and burning clearly," and is highlyrecommended for steam purposes in general. It was employed by the City of Dublin Steam Packet Company for seven years previous to February, 1849, and is at present extensively used by the Glasgow Company, the Liverpool New Tug Company, the British and Irish Steam Packet Company, and several others. The principal markets are Liverpool, Dublin, and Limerick. The shipping ports are Widnes Dock and Liverpool, from the former of which places the mine is distant eight miles, and from the latter twelve miles by railway and about thirty by canal. At the pit's mouth, or loaded on the canal, the price varies from 5*s.* 6*d.* to 7*s.* per ton: 2*s.* 6*d.* per ton is charged for carriage to Liverpool by water.

The specimen sent up for the service of the investigation was very brilliant, and possessed a distinct cubical fracture, with layers of white shale and less frequent patches of iron pyrites.

During the experiments it was found to light easily, produce a good clear fire, and blow off steam rapidly. But little ash, clinker, or cinder were left at the close of the several trials, and the furnace was found to require but little attention on the part of the stoker, as a good fire was easily maintained by merely pushing forward the partially coked coals from the dead-plate and replacing them by a fresh supply. Considerable quantities of smoke were evolved during the trials, particularly on feeding or stoking the fire.

	April 15, 1st day.	April 16, 2nd day.	April 17, 3rd day.
Fire lighted	9 h. 50 m.	9 h. 40 m.	8 h. 40 m.
Steam up	10 h. 25 m.	9 h. 55m.	8 h. 55 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	184°	211°	206°
Temperature of water in tanks	54°	58°	56°
Barometer	29·46 in.	29·15 in.	29·73 in.
Extremes of external thermometer	45°—58°	46°—56°	43°—61°
Extremes of internal thermometer	58°—64°	59°—65°	60°—67°
Dewpoint	49°·5	51°	50°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	733 lbs.	481 lbs.	523 lbs.
Weight of ashes left	6 lbs.	6 lbs.	7 lbs.
Per centage of combustible matter in ashes	24·0	29·1	54·2
Weight of cinder left	5 lbs.	6 lbs.	6 lbs.
Per centage of combustible matter in cinder	68·6	79·8	89·2

	April 15, 1st day.	April 16. 2nd day.	April 17. 3rd day.
Weight of clinker in cinder	2 lbs.	1 lb.	1 lb.
Average weight of soot in flues	·5 lb.	·5 lb.	·5 lb.
Per centage of combustible matter in soot	73·2	..	..
Weight of water evaporated	4160 lbs.	3160 lbs.	3475 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	6·80 lbs.	7·52 lbs.	7·70 lbs.
Weight of coals per hour for 1 square foot of grate surface	18·32 lbs.	12·02 lbs.	13·07 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·271	..	..
Mean weight of cubic foot of coal	47·58 lbs.	..	..
Economic weight, or space occupied by 1 ton	47·15 ft.	..	..
Cohesive power of coal	76·0	..	..

Note—Final temperature on fourth morning, 209°.

Caldwell and Thomson's Higher Delf.

I HEREBY certify that the two casks marked 5 and 6 contain a fair sample of the Higher Delf Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—CALDWELL and THOMSON *per* E. FIDLER, Jun.

This coal is extracted from the Higher Delf seam, which is worked at a depth of 170 yards from the surface, and is situated near the town of St. Helen's, Lancashire. This vein is 3 feet 6 inches in thickness, and very regular, with a dip of 1 in 3½ from north to south. The overlying and subjacent strata consist of white sandstone and flag, and the coals are extracted by the same method as the foregoing. This variety is described as "hot and durable," but requires a greater draught than the Rushy Park for its combustion. Both coals sell at the same price, are conveyed to the same markets, and when mixed form a good fuel for steam purposes. When employed alone the Higher Delf coal is much used for the evaporation of salt liquors, "for which its durability eminently fits it."

In appearance it very closely resembles the foregoing, but is more bituminous, and under the boiler less satisfactory results were obtained. Much smoke was evolved during the whole time of combustion, although for the first hour after lighting the fire it remained tolerably clear, and blew off the steam rapidly. After the expiration of a short time, however, the grate became choked, from the accumulation of a large quantity of clinker which adhered to the bars and choked the draught. At the close of each day's experiment a considerable amount of clinker was removed from the grate: the quantity of ash and cinder left was rather larger than usual.

	April 22nd.
Fire lighted	10 h. 15 m.
Steam up	10 h. 55 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	188°
Temperature of water in tanks	70°
Barometer	30·08 in.
Extremes of external thermometer	58°—74°
Extremes of internal thermometer	67°—75°
Dewpoint	54°
Area of damper open	84 in.
Weight of coals consumed	581 lbs.
Weight of ashes left	15 lbs.
Per centage of combustible matter in ashes	20·3
Weight of cinder left	9 lbs.
Per centage of combustible matter in cinder	54·5
Weight of clinker in cinder	10 lbs.
Average weight of soot in flues	..
Per centage of combustible matter in soot	..
Weight of water evaporated	3390 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	6·85 lbs.
Weight of coals per hour for 1 square foot of grate surface	16·60 lbs.
Duration of experiment	7 hrs.
Specific gravity of coal	1·274
Mean weight of cubic foot of coal	48·41 lbs.
Economic weight or space occupied by 1 ton	46·28 ft.
Cohesive power of coal	77·0

Note.—Final temperature, 208°.

Haswell Wallsend.

I hereby certify that the four casks marked Haswell Wallsend contain a fair sample of the Haswell Wallsend Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—John Taylor, *Agent.*

This coal is extracted from the Hutton seam, six miles east of Durham, and ten miles south from Sunderland. The present depth of the mine is 156 fathoms, where the seam is 4 feet 4 inches in thickness and very regular, with a dip of 1 in 30 towards the east. The overlying and subjacent strata consist of bituminous shale, and the coals are described as "the best in the north of England for household purposes." The coals are worked by the bond and wall system, and are chiefly shipped at Sunderland for the London and other markets: the present current price is 9*s.* 3*d.* per ton.

In appearance this coal is generally brilliant and has a cubical fracture. Some portions, however, have an iron-grey hue and a less regular cleavage. Both these varieties are hard, and contain large quantities of white shale between the layers, although but little iron pyrites was observed.

On the first and second days the stoking was conducted in the ordinary way. During the former part of the first day the steam was blown off rapidly, but, from the large quantities of smoke evolved, the flues soon became choked with soot, which not only impeded the draught, but also prevented the absorption of heat by the boiler, and the action was found to have considerably decreased in the latter part of the day. On the second day the draught was reduced to 6 inches, and the results obtained were proportionally less satisfactory than those of the preceding day. The coals were found to cake on the fire, and the flues were by this time nearly choked with light flocculent soot, which almost entirely prevented the further passage of smoke. On the third day a 12-inch draught was employed, and instead of first coking the coals on the dead-plate, and afterwards pushing them on to the fire, they were added in very small quantities at a time, which were thrown equally over the whole surface of the grate. An opening was also made in order to let in air behind the fire-bridge for the purpose of consuming the smoke evolved. This occasioned the soot to take fire and burn, until the flues were entirely cleared of any obstruction. By this means a good clear fire was obtained, and as by this method of stoking the smoke evolved was consumed as fast as generated, the steam was blown off rapidly throughout the remainder of the day.

It may be here remarked that the results on the second day were evidently vitiated by the non-conducting coating of soot adhering to the boiler, and that on the third day the evaporating power was slightly increased by the combustion of the carbonaceous coating of the flues.

	May 22, 1st day.	May 23, 2nd day.	May 24, 3rd day.
Fire lighted	9 h. 15 m.	9 h. 15 m.	9 h. 40 m.
Steam up	9 h. 50 m.	9 h. 35 m.	10 h. 10 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	192°	204°	200°
Temperature of water in tanks	62°	65°	60°
Barometer	29·65 in.	29·59 in.	29·48 in.
Extremes of external thermometer	52°—65°	47°—70°	52°—66°
Extremes of internal thermometer	61°—67°	62°—71°	62°—68°
Dewpoint	55°	58°	57°
Area of damper open	112 in.	84 in.	168 in.
Weight of coals consumed	384 lbs.	283 lbs.	590 lbs.
Weight of ashes left	9 lbs.	13 lbs.	12 lbs.
Per centage of combustible matter in ashes	12·7	43·9	31·0
Weight of cinder left	7 lbs.	8 lbs.	9 lbs.
Per centage of combustible matter in cinder	79·4	76·0	71·2
Weight of clinker in cinder	1 lb.	None.	1 lb.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3010 lbs.	1970 lbs.	4900 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·17 lbs.	7·80 lbs.	9·66 lbs.
Weight of coals per hour for 1 square foot of grate surface	9·60 lbs.	7·07 lbs.	14·75 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·286	..	..
Mean weight of cubic foot of coal	47·41 lbs.	..	..
Economic weight or space occupied by 1 ton	47·25 ft.	..	..
Cohesive power of coal	73·0	..	.

Note.—Final temperature on fourth morning, 208°.

Livingstone's Steam Fuel.

This fuel is made into blocks, which measure 6 inches by 4 inches by 4¼ inches, and weigh 4½ lbs. Most of them are hard, and present when broken a brilliant fracture, but many appear to have been imperfectly manufactured, being soft in the centre, and smelling strongly of gas-tar. A pile of this fuel measuring 22 × 18 × 18 inches weighed 272 lbs.

Another pile, having the same measurements, weighed 269 lbs. The mean of these two experiments gives 65·65 lbs. as the weight of one cubic foot.

Under the boiler it was found to light with difficulty, get the steam up slowly, and leave much ash. The best effects were produced when the blocks were broken into pieces weighing about 4 oz., and spread equally over the surface of the fire. When the fuel is first allowed to coke on the dead-plate much small unburnt coal falls through into the ash-pit, and on disturbing the fire accumulates to an inconvenient extent; but by the most careful stoking the proportion of ash and cinder produced was very considerable. The clinker remaining after the experiments, although much above the average weight, did not adhere to the bars: little smoke was evolved during the time of trial.

——	May 27, 1st day.	May 28, 2nd day.	May 31, 3rd day.
Fire lighted	11 h. 30 m.	9 h. 30 m.	9 h. 0 m.
Steam up	12 h. 30 m.	9 h. 50 m.	9 h. 20 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	175°	208°	198°
Temperature of water in tanks	61°	60°	66°
Barometer	29·81 in.	30·29 in.	30·28 in.
Extremes of external thermometer	49°—64°	50°—64°	50°—74°
Extremes of internal thermometer	62°—67°	62°—70°	65°—77°
Dewpoint	57°	57°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of fuel consumed	482 lbs.	401 lbs.	468 lbs.
Weight of ashes left	29 lbs.	27 lbs.	22 lbs.
Per centage of combustible matter in ashes	35·0	37·5	62·8
Weight of cinder left	22 lbs.	17 lbs.	14 lbs.
Per centage of combustible matter in cinder	84·0	75·0	84·0
Weight of clinker in cinder	9 lbs.	4 lbs.	4 lbs.
Average weight of soot in flues	None	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3835 lbs.	3610 lbs.	4170 lbs.
Weight of water evaporated from 212° by 1 lb. of fuel	9·56 lbs.	10·34 lbs.	10·19 lbs.
Weight of fuel per hour for 1 square foot of grate surface	12·05 lbs.	10·22 lbs.	11·70 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of fuel	1·184	..	..
Mean weight of cubic foot of fuel	65·65 lbs.	..	..
Economic weight or space occupied by 1 ton	34·14 ft.	..	..
Cohesive power of fuel	..	..	..

Note.—Final temperature on third morning, 208°.
Final temperature on fourth morning, 200°.

Machen Rock Vein.

I HEREBY certify that the seven casks addressed to Sir Henry de la Beche, Museum of Practical Geology, contain a fair sample of the Machen Rock Vein Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—EDW. SCOTT BARBER, *Agent.*

The Machen Colliery is situated on the Rock Vein, in the parish of Machen, Glamorganshire. The pit, which is 32 yards in depth, is sunk on the left bank of the river Rumney, about 8 miles from the town of Newport, where the produce of the mine will probably be shipped in case of the coals being exported. From the circumstance of the mine having been but recently commenced, none of its produce has yet come into the market.

The vein is worked by the pillar and stall system, and is at present 4 feet 6 inches in thickness, although it runs somewhat thinner towards the east. Both the overlying and subjacent strata consist of "cockshut rock;" and the coal is described by the agent as bituminous, with a whitish ash.

In appearance this coal very closely resembles the Abercarn.

Under the boiler it was found to light readily, blow off the steam rapidly, and afford a good clear fire. But little smoke was evolved during its combustion, and this was chiefly observed during the stoking and charging of the fire. The quantity of clinker formed was rather large; but it did not adhere to the bars, and consequently caused comparatively little inconvenience in stoking.

——	1st day.	2nd day.	3rd day.
Fire lighted	9 h. 50 m.	9 h. 40 m.	9 h. 15 m.
Steam up	10 h. 15 m.	10 h. 0 m.	9 h. 35 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	196°	210°	208°
Temperature of water in tanks	66°	63°	65°
Barometer	29·72 in.	29·84 in.	30·17 in.
Extremes of external thermometer	51°—68°	52°—67°	48°—71°

	1st day.	2nd day.	3rd day.
Extremes of internal thermometer	62°—70°	63°—68°	64°—72°
Dewpoint	53°	53°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	578 lbs.	406 lbs.	460 lbs.
Weight of ashes left	11 lbs.	8 lbs.	11 lbs.
Per centage of combustible matter in ashes	26·1	26·0	27·7
Weight of cinder left	12 lbs.	12 lbs.	14 lbs.
Per centage of combustible matter in cinder	59·8	57·0	55·8
Weight of clinker in cinder	4 lbs.	2 lbs.	2 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4650 lbs.	3250 lbs.	3830 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·36 lbs.	9·10 lbs.	9·25 lbs.
Weight of coals per hour for 1 square foot of grate surface	14·45 lbs.	10·15 lbs.	11·50 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·297	..	..
Mean weight of cubic foot of coal	48·16 lbs.	..	..
Economic weight, or space occupied by 1 ton	46·56 ft.	..	..
Cohesive power of coal	52·5	..	..

Note.—Final temperature on fourth morning, 188°.

Haydock Rushy Park.

I HEREBY certify that the three casks marked H. R. P. contain a fair sample of the Haydock Rushy Park Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD EVANS and Co.

The mine from which this coal is extracted is situated in the parish of Ashton-Mackerfield, near the town of Warrington, Lancashire, and adjoins the Liverpool and Manchester Railway. Four different seams are worked in various parts of the colliery. That from which the Rushy Park coals are extracted is 4 feet 8 inches in thickness, has a dip of 1 in 7 towards the south, and is wrought at a depth of 260 yards from the surface, where the overlying and subjacent strata consist of black shale and grey stone. The coals are described as hot and free-burning, and are employed for the generation of steam and other furnace purposes.

The specimen sent up for trial was bright, with a cubical fracture, and contained rather large quantities of iron pyrites and white shale.

During the experiments it was found to light easily, and for some time blew off steam rapidly; but after the expiration of three or four hours the grate became choked with incombustible matters, which obstructed the draught, and decreased the intensity of the fire.

The clinker formed was rather large in quantity, and, from its adhering firmly to the bars, is difficult to remove from the grate. Much smoke was evolved during the combustion of these coals.

	June 11, 1st day.	June 12, 2nd day.	June 13, 3rd day.
Fire lighted	10 h. 5 m.	4 h. 40 m.	8 h. 45 m.
Steam up	10 h. 15 m.	4 h. 50 m.	9 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	208°	212°	206°
Temperature of water in tanks	72°	67°	65°
Barometer	29·96 in.	29·90 in.	..
Extremes of external thermometer	54°—79°	51°—72°	50°—67°
Extremes of internal thermometer	70°—79°	64°—72°	65°—68°
Dewpoint	55°	53°	52°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	542 lbs.	436 lbs.	464 lbs.
Weight of ashes left	8 lbs.	7 lbs.	6 lbs.
Per centage of combustible matter in ashes	52·4	61·0	42·1
Weight of cinder left	8 lbs.	7 lbs.	8 lbs.
Per centage of combustible matter in cinder	67·5	77·0	73·7
Weight of clinker in cinder	2 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4180 lbs.	3280 lbs.	3620 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·82 lbs.	8·48 lbs.	8·92 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·55 lbs.	10·90 lbs.	11·60 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·323	..	..
Mean weight of cubic foot of coal	49·33 lbs.	..	..
Economic weight or space occupied by 1 ton	45·43 ft.	..	..
Cohesive power of coal	77·0	..	..

Note.—Final temperature on fourth morning, 206°.

Haydock Little Delf.

I HEREBY certify that the three casks marked H. L. D., Nos. 1, 2, and 3, contain a fair sample of the Haydock Little Delf Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD EVANS and Co.

This coal is extracted from the same mine as the preceding variety, and is raised from a depth of 320 feet from the surface. The vein is 3 feet 6 inches in thickness, and has a dip of 1 in 7 towards the south. The overlying and subjacent strata are composed of "shale and stone;" and the coals are chiefly used by smiths, and for making coke.

In appearance this coal closely resembles the foregoing, but is more bituminous, softer, and less bright; contains large quantities of white shale and mineralized charcoal, although but little iron pyrites was observed.

During the experiments it was found to cake slightly on the fire, burn freely, and blow off the steam rapidly, with the evolution of much smoke. Little ash or clinker remained at the close of the experiments; and the latter did not adhere very firmly to the bars. The details of the experiments will be found in the subjoined table:—

	June 17. 1st day.	June 18, 2nd day.	June 19, 3rd day.
Fire lighted	9 h. 30 m.	7 h. 45 m.	9 h. 0 m.
Steam up	9 h. 50 m.	7 h. 55 m.	9 h. 10 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	170°	210°	211°
Temperature of water in tanks	60°	66°	68°
Barometer	30·31 in.	30·40 in.	30·43 in.
Extremes of external thermometer	45°—66°	53°—73°	57°—76°
Extremes of internal thermometer	61°—65°	63°—74°	68°—77°
Dewpoint	59°	54°	54°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	682 lbs.	433 lbs.	517 lbs.
Weight of ashes left	7 lbs.	8 lbs.	8 lbs.
Per centage of combustible matter in ashes	39·0	42·4	33·6
Weight of cinder left	6 lbs.	7 lbs.	7 lbs.
Per centage of combustible matter in cinder	63·2	61·7	69·0
Weight of clinker in cinder	3 lbs.	2 lbs.	2 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	5150 lbs.	3440 lbs.	4200 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·05 lbs.	9·07 lbs.	9·27 lbs.
Weight of coals per hour for 1 square foot of grate surface	17·05 lbs.	10·82 lbs.	12·92 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·257	..	..
Mean weight of cubic foot of coal	44·91 lbs.	..	..
Economic weight, or space occupied by 1 ton	49·88 ft.	..	..
Cohesive power of coal	66·5	..	..

Note.—Final temperature on fourth morning, 211°.

Haydock Higher Florida.

I HEREBY certify that the three casks marked H. H. F., Nos. 1, 2, and 3, contain a fair sample of the Haydock Higher Florida Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD EVANS and Co.

This colliery is situated in the same parish as the two preceding mines. The vein from which the Higher Florida coals are extracted is 4 feet 4 inches in thickness. and has a dip of 1 in 7 towards the south. This coal is at present wrought at a depth of 250 yards from the surface, where the overlying and subjacent strata consist of dark shale, black rock, and grit.

They are described as "clean, hot, and durable;" and are largely used by the ocean steamers from the Mersey, and at the salt-works in Cheshire.

This coal is very brilliant, and has a cubical fracture, but contains considerable quantities of white shale and iron pyrites, particularly on the planes of cleavage, where a little brown coal and mineralized charcoal are also occasionally met with.

Under the boiler they lighted easily, and for some time blew off the steam rapidly; but at the expiration of a few hours the grate became choked by the accumulation of clinker, which adhered firmly to the bars and impeded the draught.

The amount of clinker found after the experiment was much above the average quantity; but from the smallness of the fragments, and the difficulty of separating them entirely from the ash, the number, relative to their weights, given in the following table will be rather under the truth:—

	June 20, 1st day.	June 21, 2nd day.	June 22, 3rd day.
Fire lighted	9 h. 55 m.	9 h. 35 m.	7 h. 55 m.
Steam up	10 h. 5 m.	9 h. 40 m.	8 h. 5 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	211°	212°	208°
Temperature of water in tanks	70°	72°	72°
Barometer	30·31 in.	30·27 in.	30·32 in.
Extremes of external thermometer	59°—78°	56°—79°	63°—83°
Extremes of internal thermometer	72°—79°	73°—80°	74°—83°
Dewpoint	55°	56°	58°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	604 lbs.	414 lbs.	500 lbs.
Weight of ashes left	7 lbs.	7 lbs.	8 lbs.
Per centage of combustible matter in ashes	22·0	33·0	28·7
Weight of cinder left	6 lbs.	9 lbs.	7 lbs.
Per centage of combustible matter in cinder	64·0	55·8	47·9
Weight of clinker in cinder	4 lbs.	2 lbs.	3 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	4400 lbs.	3080 lbs.	3740 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·30 lbs.	8·37 lbs.	8·51 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·10 lbs.	10·35 lbs.	12·50 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·218	..	..
Mean weight of cubic foot of coal	49·50 lbs.	..	..
Economic weight or space occupied by 1 ton	45·25 ft.	..	..
Cohesive power of coal	74·0	..	..

Note.—Final temperature on fourth morning, 208°.

Haydock Florida Main Seam.

I HEREBY certify that the three hogsheads marked H. M. F., Nos. 1, 2, and 3, contain a fair sample of the Haydock Florida Main Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—RICHARD EVANS & Co.

These coals are extracted from the same mine as the foregoing, and are raised from a vein about 10 yards below the *higher* seam. The roof is composed of fire-clay and shale, and the underlying strata consist of dark shale and grit-stone. This vein is 6 feet in thickness, and tolerably regular. The inclination is similar to that of the Higher Florida Seam, and the produce finds the same markets.

These coals very closely resemble the foregoing both in their appearance and behaviour under the boiler. The practical results obtained will be found in the following table:—

	June 26, 1st day.	June 27, 2nd day.	June 28, 3rd day.
Fire lighted	6 h. 50 m.	9 h. 5 m.	3 h. 45 m.
Steam up	7 h. 0 m.	9 h. 15 m.	4 h. 0 m.
Weight of wood used	10 lbs.	10 lbs.	10 lbs.
Initial temperature of water in boiler	211°	206°	211°
Temperature of water in tanks	70°	64°	66°
Barometer	30·01 in.	29·98 in.	29·78 in.
Extremes of external thermometer	56°—70°	55°—72°	56°—72°
Extremes of internal thermometer	71°—80°	70°—74°	70°—73°
Dewpoint	57°	56°	57°
Area of damper open	112 in.	56 in.	84 in.
Weight of coals consumed	544 lbs.	380 lbs.	559 lbs.
Weight of ashes left	7 lbs.	10 lbs.	9 lbs.
Per centage of combustible matter in ashes	34·6	38·0	37·6
Weight of cinder left	6 lbs.	11 lbs.	10 lbs.
Per centage of combustible matter in cinder	57·5	68·3	59·0
Weight of clinker in cinder	3 lbs.	1 lb.	2 lbs.
Average weight of soot in flues	..	..	..
Per centage of combustible matter in soot	..	..	..
Weight of water evaporated	3730 lbs.	2670 lbs.	3740 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	7·74 lbs.	8·11 lbs.	7·64 lbs.
Weight of coals per hour for 1 square foot of grate surface	13·80 lbs.	9·50 lbs.	13·97 lbs.
Duration of experiment	8 hrs.	8 hrs.	8 hrs.
Specific gravity of coal	1·267	..	..
Mean weight of cubic foot coal	48·04 lbs.	..	..
Economic weight or space occupied by 1 ton	46·66 ft.	..	..
Cohesive power of coal	81·5	..	..

Note.—Final temperature on fourth morning, 212°.

Mirfa Four-Feet Steam Coals.

We hereby certify that the four boxes marked M. 1, 2, 3, and 4, and two casks marked 9 and 10, contain a fair sample of the Mirfa Four-Feet Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—Vivian & Sons, *Proprietors.*

This coal is extracted from the Four-Feet Seam at Mirfa Manor Farm, in the parish of Margam, Glamorganshire, and is at present worked by "stall and pillar" to the depth of 80 fathoms, where the vein varies from 4 to 5 feet in thickness, and has an inclination of from 12 to 18 inches towards the north.

The overlying and subjacent strata consist of shale and sandstone, and the coals are described as "bituminous and coking."

The shipping port is Swansea, from whence the produce of the mine is chiefly exported to Cornwall and Ireland. The present current price for screened coals, delivered on board ship, is 7*s.* 6*d.* per ton.

These coals were found to cake under the boiler, which impeded the draught and caused the fire to require constant stirring in order to keep up the steam. Much smoke was evolved during the experiments, and the clinker, although not large in quantity, adhered to the bars, and required constant attention on the part of the stoker to prevent its choking the fire. From the slow combustion of the coal it was not found to generate a great quantity of steam in a given time; but like all others of the same variety possesses a high evaporating coefficient.

	July 2, 1st day.	July 3, 2nd day.
Fire lighted	9 h. 15 m.	10 h. 20 m.
Steam up	9 h. 40 m.	10 h. 40 m.
Weight of wood used	10 lbs.	10 lbs.
Initial temperature of water in boiler	198°	200°
Temperature of water in tanks	64°	68°
Barometer	30·01 in.	..
Extremes of external thermometer	55°—69°	57°—72°
Extremes of internal thermometer	64°—70°	65°—73°
Dewpoint	51°	56°
Area of damper open	112 in.	168 in.
Weight of coals consumed	404 lbs.	465 lbs.
Weight of ashes left	10 lbs.	9 lbs.
Per centage of combustible matter in ashes	18·6	19·2
Weight of cinder left	9 lbs.	11 lbs.
Per centage of combustible matter in cinder	62·8	78·8
Weight of clinker in cinder	3 lbs.	4 lbs.
Average weight of soot in flues	..	..
Per centage of combustible matter in soot	..	..
Weight of water evaporated	3150 lbs.	3590 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·91 lbs.	8·93 lbs.
Weight of coals per hour for 1 square foot of grate surface	10·10 lbs.	11·62 lbs.
Duration of experiment	8 hrs.	8 hrs.
Specific gravity of coal	1·299	..
Mean weight of cubic foot of coal	47·99 lbs.	..
Economic weight or space occupied by 1 ton	46·76 ft.	..
Cohesive power of coal	54·0	..

Note.—Final temperature on third morning, 209°.

Vivian and Sons' Rock Vawr Coal.

We hereby certify that the four casks marked R. V. 5, 6, 7, 8, contain a fair sample of the Rock Vawr Steam Coals, which were mined specially for the service of the "Admiralty Coals Investigation."—Vivian & Sons, *Proprietors.*

This vein, which varies from 3 feet 6 inches to 4 feet in thickness, is worked by level at a farm called Brambill, in the parish of Margam, Glamorganshire. The overlying and subjacent strata consist of sandstone, which together with the vein itself has a dip of about 3 inches in the yard towards the north. The coal is extracted by pillar and stall, and is described as "free, and not caking on the fire." This variety sells at the same price as the preceding, and is shipped at Swansea for the same markets.

During the several trials these coals were found to light readily and blow off the steam rapidly; but this, like the preceding variety, was found after a short time to choke the grate, from the accumulation of a very fusible clinker, which adhered so firmly to the bars as to render its removal, previous to the termination of the experiment, extremely difficult. Considerable quantities of smoke were evolved during the experiments, and at their termination a larger amount of clinker was found adhering to the bars than in the case of the Mirfa coals.

	July 4, 1st day.	July 5, 2nd day.
Fire lighted	8 h. 0 m.	7 h. 35 m.
Steam up	8 h. 10 m.	7 h. 45 m.
Weight of wood used	10 lbs.	10 lbs.
Initial temperature of water in boiler	209°	210°
Temperature of water in tanks	62°	65°
Barometer	29·87 in.	30·24 in.
Extremes of external thermometer	50°—69°	50°—69°
Extremes of internal thermometer	64°—69°	65°—70°
Dewpoint	60°	53°
Area of damper open	112 in.	84 in.
Weight of coals consumed	610 lbs.	504 lbs.
Weight of ashes left	10 lbs.	8 lbs.
Per centage of combustible matter in ashes	13·3	13·4
Weight of cinder left	11 lbs.	9 lbs.
Per centage of combustible matter in cinder	63·8	59·2
Weight of clinker in cinder	6 lbs.	9 lbs.
Average weight of soot in flues	..	..
Per centage of combustible matter in soot	..	..
Weight of water evaporated	4320 lbs.	3560 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	8·13 lbs.	8·04 lbs.
Weight of coals per hour for 1 square foot of grate surface	15·25 lbs.	12·60 lbs.
Duration of experiment	8 hrs.	8 hrs.
Specific gravity of coal	1·301	..
Mean weight of cubic foot of coal	48·99 lbs.	..
Economic weight or space occupied by 1 ton	45·80 ft.	..
Cohesive power of coal	70·5	..

Note.—Final temperature on third morning, 208°.

Experiment on a Mixture of the two foregoing Coals.

It having been stated by the proprietors that an excellent fuel for steam purposes is obtained by the mixture of the two preceding coals, it was thought expedient to make trial of a compound, having the composition of one part by weight of Mirfa coal and two parts of Rock Vawr.

This was found to light readily and burn freely; but unless the two coals are carefully mixed, the fuel has a tendency, from the different properties of the two ingredients, to cake on one part of the grate, and burn in holes on another. This rendered great attention necessary on the part of the stoker, in order to prevent the passage of cold air through the holes formed, and the consequent loss of heat it would occasion.

When carefully mixed, it is probable that this inconvenience would not be felt in larger fireplaces where the combustion of considerable masses of fuel is effected; but the experimental boiler being small, it was found difficult to obviate entirely this inconvenience. Much smoke was evolved during the experiment, and towards its close much trouble was occasioned by the accumulation of clinker, which adhered so firmly to the bars as to render its removal almost impossible.

	July 6.
Fire lighted	8 h. 25 m.
Steam up	8 h. 35 m.
Weight of wood used	10 lbs.
Initial temperature of water in boiler	208°
Temperature of water in tanks	65°
Barometer	30·09 in.
Extremes of external thermometer	50°—70°
Extremes of internal thermometer	63°—71°
Dewpoint	54°
Area of damper open	112 in.
Weight of coals consumed	517 lbs.
Weight of ashes left	9 lbs.
Per centage of combustible matter in ashes	..
Weight of cinder left	5 lbs.
Per centage of combustible matter in cinder	..
Weight of clinker in cinder	9 lbs.
Average weight of soot in flues	..
Per centage of combustible matter in soot	..
Weight of water evaporated	4200 lbs.
Weight of water evaporated from 212° by 1 lb. of coal	9·07 lbs.
Weight of coals per hour for 1 square foot of grate surface	12·92 lbs.
Duration of experiment	8 hrs.
Specific gravity of coal	..
Mean weight of cubic foot of coal	..
Economic weight or space occupied by 1 ton	..
Cohesive power of coal	..

Note.—Final temperature, 190°.

SUMMARY.

NAME OF COAL.	Evaporative power, or number of pounds of Water evaporated from 212° by 1 lb. of Coal.	Weight of one cubic foot of the Coal as used for Fuel.	Weight of one cubic foot of the Coal as calculated from the density.	Ratio of B to C, or of the economic to the theoretical weights.	Difference per cent. between theoretical and economic weights.	Space occupied by 1 ton in cubic feet (economic weight).	Results of experiments on cohesive power of Coals.	Evaporative power of Coals, after deducting for the combustible matter in the residue.	Per centage of residue in the Coal. — Mean.	Weight of Water evaporated from 212° by 1 cubic foot.	Pounds of Clinker per ton of Coal.	Per centage amount of Coke.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.
od	9·95	53·2	79·87	·666	50·13	42·10	43·0	10·16	5·61	529·34	7·0	72·19
Close.	9·38	50·6	79·87	·633	57·84	44·26	38·5	9·67	5·53	474·62	6·6	69·69
Four-Foot Seam	7·77	53·4	75·49	·707	41·36	41·94	75·0	8·05	7·98	414·91	37·6	60·0
. . . . .	8·08	50·8	81·10	·626	59·64	44·09	78·5	8·35	10·06	410·46	47·1	62·4
. . . . .	7·02	50·4	79·54	·633	57·81	44·44	. .	7·16	4·72	353·80	4·4	54·5
n	8·97	58·1	85·97	·675	47·96	38·55	. .	9·07	17·63	521·15	34·7	82·0
ll Pemberton Four Feet .	8·34	51·8	79·60	·650	53·66	43·24	74·5	8·45	3·52	399·89	2·1	57·1
ll Pemberton Five Feet .	7·72	51·8	79·17	·654	52·83	43·24	71·5	7·95	8·74	399·89	20·4	56·5
l Pemberton Yard . . .	8·78	48·0	84·10	·570	75·20	46·66	75·5	. .	4·90	421·44	10·8	60·6
ll Co.'s Furnace Vein . .	7·47	49·3	81·98	·601	66·28	45·43	71·5	7·84	7·40	368·27	25·3	58·4
and Green's Patent Fuel .	7·59	64·8	81·23	·797	25·35	34·56	. .	7·86	12·55	491·83	87·6	. .
ove Graigola	9·22	51·0	84·85	·601	66·37	43·92	59·0	9·64	9·89	470·22	28·6	85·1
. . . . .	6·91	47·3	80·54	·587	70·27	47·35	62·0	7·02	4·10	326·84	14·1	50·8
ll Pemberton Four Feet .	8·52	47·3	78·48	·602	65·91	47·35	71·5	8·65	3·39	402·99	7·1	55·7
ll Pemberton Five Feet .	7·13	48·3	80·04	·603	65·71	46·37	78·5	7·29	6·35	354·04	31·9	56·1
ll Co.'s New Mine. . .	7·04	48·4	79·73	·607	64·73	46·28	76·5	7·16	5·86	340·73	34·2	57·7
and Elsecar Co.'s . . .	8·07	48·2	82·16	·586	70·45	46·47	82·5	8·43	7·90	388·97	1·7	62·5
n Merthyr	9·53	51·4	80·98	·634	57·54	43·57	74·0	10·04	7·38	489·84	13·0	85·4
william's Elsecar . . .	8·52	47·2	80·85	·583	71·29	47·45	77·0	8·78	5·95	402·14	6·6	60·8
william's Park Gate . .	7·92	47·0	81·79	·574	74·02	47·65	78·0	8·24	7·60	372·24	None	61·7
rtley Main	7·87	48·9	78·86	·620	61·26	45·80	79·0	8·05	4·40	384·84	2·8	59·2
Co.'s Portland Hard . .	7·92	47·1	81·16	·580	72·31	47·55	89·0	8·04	4·39	373·03	10·3	60·9
Co.'s Langley Hard . .	7·80	47·8	78·86	·606	64·97	46·86	84·5	7·98	6·48	372·84	10·0	54·0
Main.	8·36	47·0	81·10	·579	72·55	47·65	. .	8·56	5·12	392·92	10·7	55·4
l Co.'s Arley	9·13	47·6	79·36	·599	66·72	47·05	73·5	9·35	5·60	434·58	10·7	64·0
Co.'s Bagilt Main . . .	8·33	49·6	79·17	·626	59·61	45·16	79·0	8·50	3·92	413·16	5·7	55·8
ck Skerrington. . . .	7·66	44·7	77·42	·577	73·19	50·11	63·5	7·82	3·42	342·40	6·4	49·3
Two Yard	7·85	47·9	80·04	·598	67·11	46·76	79·5	7·91	5·60	376·01	19·5	56·2
. . . . .	9·47	50·3	83·22	·604	65·44	44·53	54·5	9·63	4·83	476·34	20·0	68·4
n Merthyr (2nd Sample) .	10·75	48·9	81·91	·597	67·50	45·80	. .	. .	6·50	525·67	13·3	84·7
oft	6·88	44·8	80·17	·558	78·95	50·00	62·0	6·99	3·36	308·22	8·4	52·8
lard	6·32	45·9	79·60	·576	73·42	48·80	86·0	. .	4·64	290·08	8·5	56·5
and Thomson's Rushy Park	7·34	47·5	79·29	·599	66·92	47·15	76·0	7·43	2·38	348·65	5·1	58·7
and Thomson's Higher Delf	6·85	48·4	79·48	·608	64·21	46·28	77·0	6·94	5·85	331·54	38·6	54·2
Wallsend	8·87	47·4	80·23	·590	69·26	47·25	73·0	9·07	4·77	420·43	3·5	62·7
one's Steam Fuel . . .	10·03	65·6	73·86	·888	12·59	34·14	. .	10·57	10·95	657·96	28·2	. .
Rock Vein	9·23	48·1	80·91	·594	68·21	46·56	52·5	9·43	5·26	443·96	12·4	65·2
Rushy Park	8·74	49·3	82·54	·597	67·42	45·43	77·0	8·91	3·39	430·88	7·8	59·4
Little Delf	9·13	44·9	78·42	·572	74·65	49·88	66·5	9·26	5·51	409·93	9·6	58·1
Higher Florida. . . .	8·39	49·5	75·99	·651	53·51	45·25	74·0	8·49	3·62	415·30	13·2	51·1
Florida Main	7·83	48·0	79·04	·507	64·66	46·66	81·5	7·97	3·97	375·84	9·0	54·4
nd Sons' Mirfa Coal . .	8·92	47·9	81·04	·591	69·18	46·76	54·0	9·11	5·29	427·26	18·0	67·1
nd Sons' Rock Vawr . .	8·08	48·9	81·16	·602	65·97	45·80	70·5	8·19	4·75	395·11	30·1	58·6

LITHARGE EXPERIMENTS.*

NAME OF COAL.	1st Experiment.	2nd Experiment.	3rd Experiment.	Mean.
Willington	158·0	155·0	..	156·5
Bowden Close	158·0	159·0	..	158·5
Wigan Four-feet Seam	150·0	150·1	150·1	150·1
King Coal	136·1	136·2	137·0	136·4
Ewloe	135·0	135·2	136·7	135·6
Cadoxton	157·2	159·8	157·0	158·0
Ince Hall Pemberton Four-feet	143·1	145·8	144·1	144·3
Ince Hall Pemberton Five-feet	144·2	143·9	143·0	143·7
Ince Hall Pemberton Yard	150·0	150·8	149·9	150·2
Ince Hall Co.'s Furnace Vein	143·1	143·2	142·8	143·0
Hollands and Green's Fuel	118·2	118·7	118·3	118·4
Birch Grove Graigola	168·9	164·1	166·0	166·3
Ibstock	125·9	124·8	125·8	125·5
Moss Hall Pemberton Four-feet	140·3	142·2	145·0	142·5
Moss Hall Pemberton Five-feet	137·1	140·0	135·2	137·4
Moss Hall Co.'s New Mine.	134·5	135·6	135·4	135·1
Hoyland and Elsecar Co.'s	150·0	147·0	148·7	148·6
Aberaman Merthyr	159·9	159·9	160·0	159·9
Earl Fitzwilliam's Elsecar	149·2	151·0	151·3	150·5
Earl Fitzwilliam's Park Gate	150·6	150·2	151·0	150·6
West Hartley Main	152·2	150·3	153·0	151·8
Butterly Co.'s Portland Hard	154·2	156·0	155·5	155·2
Butterly Co.'s Langley Hard	149·4	151·9	148·8	150·0
Brymbo Main	153·0	151·8	150·7	151·8
Ince Hall Co.'s Arley	160·0	163·1	164·5	162·5
Coleshill Co.'s Bagilt	153·8	151·2	151·1	152·0
Kilmarnock Skerrington	150·1	152·0	152·8	151·6
Brymbo Two Yard	147·7	147·0	148·0	147·5
Abercarn	153·1	153·9	154·5	153·8
Loscoe Soft	140·2	139·0	141·6	140·2
Loscoe Hard	147·0	148·7	148·0	147·9
Caldwell and Thomson's Rushy Park	146·6	147·0	147·8	147·1
Haswell Wallsend	157·0	157·7	157·9	157·5
Livingstone's Steam Fuel	161·0	163·9	164·0	162·7
Machen Rock Vein	152·8	153·0	154·2	153·3
Caldwell and Thomson's Little Delf	141·5	141·0	143·1	141·8
Haydock Rushy Park	148·0	149·5	149·6	149·0
Haydock Little Delf	148·0	146·1	145·9	146·6
Haydock Higher Florida	148·0	147·9	149·9	148·6
Haydock Main Florida	147·1	146·2	145·8	146·3
Vivian and Sons' Mirfa Coal	156·0	155·2	154·1	155·1
Vivian and Sons' Rock Vawr.	150·2	149·9	150·0	150·0

* Weight of Coals operated on = 5 grains.

Analyses of Coals, by T. T. Philipps.

Experimental Numbers, found in Analysis.

Willington.

This coal contained 1·11 per cent. of water: dried at 212° Fah.

Coal.			
3·18	grs. gave	10.10	carbonic acid and 1·47 water.
3·13	,,	9·99	,, 1·35 ,,
9·78	,,	·09	ash.
15·36	,,	·18	,,
14·76	,,	2·47	platinum salt.
13·56	,,	0·88	sulphate of baryta.

Bowden Close.

This coal contained 1·33 per cent. of water: dried at 212° Fah.

Coal.			
3·71	grs. gave	11·52	carbonic acid and 1·51 water.
3·28	,,	10·25	,, 1·33 ,,
12·30	,,	·29	ash.
12·12	,,	·27	,,
11·50	,,	2·70	platinum salt.
12·57	,,	·66	sulphate of baryta.

Wigan Four-Foot.

This coal contained 2·69 per cent. of water: dried at 212° Fah.

Coal.			
4·52	grs. gave	13·10	carbonic acid and 2·21 water.
4·09	,,	11·80	,, 1·90 ,,
17·09	,,	·73	ash.
14·73	,,	·62	,,
13·21	,,	1·82	platinum salt.
11·48	,,	1·00	sulphate of baryta.

King.

This coal contained 2·84 per cent. of water: dried at 212° Fah.

Coal.			
3·35	grs. gave	9·04	carbonic acid and 1·61 water.
3·31	,,	8·95	,, 1·57 ,,
14·29	,,	1·24	ash.
13·32	,,	1·17	,,
15·15	,,	4·07	platinum salt.
14·01	,,	1·57	sulphate of baryta.

Ewloe.

This coal contained 6·83 per cent. of water: dried at 212° Fah.

Coal.			
3·53	grs. gave	10·50	carbonic acid and 1·56 water.
3·56	,,	10·55	,, 1·61 ,,
12·68	,,	·42	ash.
14·81	,,	·51	,,
11·23	,,	1·98	platinum salt.
11·75	,,	1·20	sulphate of baryta.

Cadoxton.

This coal contained 1·52 per cent. of water: dried at 212° Fah.

Coal.			
3·565	grs. gave	11·455	carbonic acid and 1·380 water.
3·765	,,	12·120	1·490 ,,
11·92	,,	·43	ash.
11·89	,,	·42	,,
13·77	,,	2·32	platinum salt.
12·83	,,	1·64	sulphate of baryta.

Ince Hall Pemberton Four Feet.

This coal contained 4·86 per cent. of water: dried at 212° Fah.

Coal.			
5·20	grs. gave	14·705	carbonic acid and 1·69 water.
3·87	,,	10·92	,, 1·49 ,,
13·20	,,	·14	ash.
12·33	,,	·14	ash.
14·37	,,	3·22	platinum salt.
12·76	,,	·98	sulphate of baryta.

Ince Hall Pemberton Five Feet.

This coal contained 4·75 per cent. of water: dried at 212° Fah.

Coal.				
3·365	grs. gave	8·53	carbonic acid and	1·54 water
3·365	,,	8·43	,,	1·35 ,,
16·46	,,	2·37 ash.		
12·45	,,	1·78 ,,		
13·64	,,	4·79 platinum salt.		
13·31	,,	1·32 sulphate of baryta.		

Ince Hall Pemberton Yard.

This coal contained 2·55 per cent. of water: dried at 212° Fah.

Coal.				
3·40	grs. gave	10·02	carbonic acid and	1·80 water.
3·40	,,	10·12	,,	2·02 ,,
12·64	,,	·30 ash.		
13·40	,,	·30 ,,		
18·84	,,	3·91 platinum salt.		
13·00	,,	1·73 sulphate of baryta.		

Ince Hall Co.'s Furnace Vein.

This coal contained 5·33 per cent. of water: dried at 212° Fah.

Coal.				
3·11	grs. gave	8·48	carbonic acid and	1.57 water.
3·18	,,	8·76	,,	1.64 ,,
9·12	,,	·37 ash.		
9·65	,,	·39 ,,		
11·56	,,	2·82 platinum salt.		
12·40	,,	·87 sulphate of baryta.		

Hollands and Green's Patent Fuel.

This fuel contained 2·18 per cent. of water: dried at 212° Fah.

Fuel.		
12·44	,,	1·73 ash.
15·34	,,	2·08 ,,

Birch Grove Graigola.

This coal contained 1·51 per cent. of water: dried at 212° Fah.

Coal.				
3·73	grs. gave	11·52	carbonic acid and	1·44 water.
4·68	,,	14·46	,,	1·70 ,,
16·63	,,	·75 ash.		
14·64	,,	·64 ,,		
13·83	,,	1·62 platinum salt.		
13·43	,,	·85 sulphate of baryta.		

Ibstock.

This coal contained 1·12 per cent of water: dried at 212° Fah.

Coal.				
3·52	grs. gave	9·71	carbonic acid and	1·51 water.
3·73	,,	10·22	,,	1·65 ,,
13·05	,,	·77 ash.		
9·68	,,	·59 ,,		
12·03	,,	1·69 platinum salt.		
11.14	,,	1·18 sulphate of baryta.		

Moss Hall Pemberton Four Feet.

This coal contained 3·32 per cent. of water: dried at 212° Fah.

Coal.				
3·17	grs. gave	8·80	carbonic acid and	1·33 water.
3·38	,,	9·34	,,	1·52 ,,
14·86	,,	1·01 ash.		
15·05	,,	·96 ,,		
12·38	,,	4·08 platinum salt.		
12·21	,,	2·71 sulphate baryta.		

Moss Hall Pemberton Five Feet.

This coal contained 3·69 per cent. of water, dried at 212° Fah.

Coal.				
3·57	grs. gave	9·92	carbonic acid and	1·74 water.
3·21	,,	9·01	,,	1·53 ,,
11·80	,,	·71 ash.		
11·10	,,	.67 ,,		
16·58	,,	3·42 platinum salt.		
12·90	,,	2·99 sulphate of baryta.		

Moss Hall Co.'s New Mine.

This coal contained 6·76 per cent. of water: dried at 212° Fah.

Coal.			
3·48	grs. gave	9·91	carbonic acid and 1·57 water.
3·45	,,	9·78	,, 1·41 ,,
11·15	,,	·36	ash.
15·79	,,	·49	,,
12·23	,,	1·92	platinum salt.
11·31	,,	1·13	sulphate of baryta.

Hoyland and Elsecar.

This coal contained 3·72 per cent. of water: dried at 212° Fah.

Coal.			
3·39	grs. gave	9·96	carbonic acid and 1·53 water.
3·29	,,	9·65	,, 1·44 ,,
14·95	,,	·57	ash.
11·50	,,	·42	,,
12·30	,,	2·44	platinum salt.
9·63	,,	·75	sulphate baryta.

Aberaman Merthyr.

This coal contained 0·41 per cent. of water: dried at 212° Fah.

Coal.			
2·15	grs. gave	7·15	carbonic acid and ·83 water.
3·86	,,	12·91	,, 1·51 ,,
9·90	,,	·15	ash.
12·07	,,	·17	,,
13 40	,,	2·59	platinum salt.
12·11	,,	1·05	sulphate of baryta.

Earl Fitzwilliam's Elsecar.

This coal contained 4·83 per cent. of water: dried at 212° Fah.

Coal.			
3·55	grs. gave	10·67	carbonic acid and 1·56 water.
3·63	,,	10·90	,, 1·58 ,,
14·27	,,	·35	ash.
17·02	,,	·42	,,
11·47	,,	2·32	platinum salt.
12·80	,,	·85	sulphate of baryta.

Earl Fitzwilliam's Park Gate.

This coal contained 3·08 per cent. water: dried at 212° Fah.

Coal.			
3·13	grs. gave	9·19	carbonic acid and 1·45 water.
3·30	,,	9·69	,, 1·40 ,,
13·54	,,	·24	ash.
12·00	,,	·22	,,
14·90	,,	5·12	platinum salt.
10·37	,,	·84	sulphate baryta.

West Hartley Main.

This coal contained 6·76 per cent. water: dried at 212° Fah.

Coal.			
3·70	grs. gave	11·11	carbonic acid and 1·74 water.
3·41	,,	10·23	,, 1·65 ,,
12·60	,,	·32	ash.
11·68	,,	·29	,,
12·83	,,	3·46	platinum salt.
12·00	,,	·99	sulphate baryta.

Butterly Co.'s Portland.

This coal contained 7·36 per cent. of water: dried at 212° Fah.

Coal.			
3·46	grs. gave	10·20	carbonic acid and 1·43 water.
2·96	,,	8·73	,, 1·26 ,,
13·80	,,	·18	ash.
12·04	,,	·14	,,
14·76	,,	3·75	platinum salt.
14·50	,,	·92	sulphate baryta.

Butterly Co.'s Langley.

This coal contained 3·55 per cent. of water: dried at 212° Fah.

Coal.			
3·58	grs. gave	10·20	carbonic acid and 1·84 water.
3·60	,,	10·33	,, 1·77 ,,
10·43	,,	·50	ash.
11·05	,,	·50	,,
13·18	,,	1·68	platinum salt.
11·26	,,	·94	sulphate of baryta.

Brymbo Main.

This coal contained 4·50 per cent. of water: dried at 212° Fah.

Coal.			
3·23	grs. gave	9·16	carbonic acid and 1·51 water.
3·36	,,	9·96	,, 1·51 ,,
11·82	,,	·50	ash.
12·56	,,	·53	,,
11·48	,,	1·05	platinum salt.
12·12	,,	2·42	sulphate baryta.

Ince Hall Arley.

This coal contained 1·07 per cent. of water: dried at 212° Fah.

Coal.			
3·00	grs. gave	9·05	carbonic acid and 1·50 water.
3·33	,,	10·13	,, 1·85 ,,
5·94	,,	·10	ash.
5·02	,,	·07	,,
10·18	,,	2·86	platinum salt.
6·44	,,	·38	sulphate baryta.

Coleshill Co.'s Bagilt Main.

This coal contained 5·50 per cent. of water: dried at 212° Fah.

Coal.			
3·56	grs. gave	11·60	carbonic acid and 1·89 water.
3·29	,,	10·63	,, 1·59 ,,
16·13	,,	·26	ash.
14·10	,,	·23	,,
10·70	,,	3·61	platinum salt.
11·43	,,	1·14	sulphate baryta.

Kilmarnock Skerrington.

This coal contained 7·76 per cent. of water: dried at 212° Fah.

Coal.			
3·47	grs. gave	10·18	carbonic acid and 1·83 water.
3·39	,,	9·96	,, 1·77 ,,
14·04	,,	·18	ash.
11·40	,,	·14	,,
11·36	,,	1·70	platinum salt.
11·46	,,	·72	sulphate baryta.

Brymbo Two Yard.

This coal contained 3·35 per cent. of water: dried at 212° Fah.

Coal.			
3·63	grs. gave	10·43	carbonic acid and 1·64 water.
3·14	,,	8·97	,, 1·71 ,,
16·24	,,	·97	ash.
13·68	,,	·80	,,
11·66	,,	1·02	platinum salt.
11·23	,,	1·54	sulphate baryta.

Abercarn.

This coal contained 7·11 per cent. of water: dried at 212° Fah.

Coal.			
3·62	grs. gave	10·76	carbonic acid and 2·09 water.
3·14	,,	9·38	,, 1·76 ,,
6·90	,,	·14	ash.
8·95	,,	·18	,,
13·93	,,	1·71	platinum salt.
11·12	,,	1·31	sulphate baryta.

Loscoe Soft.

This coal contained 9·76 per cent. of water: dried at 212° Fah.

Coal.				
3·34	grs. gave	9·46	carbonic acid and	1·46 water.
3·08	,,	8·78	,,	1·35 ,,
10·89	,,	·25	ash.	
14·21	,,	·33	,,	
13·08	,,	3·42	platinum salt.	
11·98	,,	1·14	sulphate baryta.	

Caldwell and Thomson's Rushy Park.

This coal contained 4·97 per cent. of water: dried at 212° Fah.

Coal.				
3·47	grs. gave	9·68	carbonic acid and	1·75 water.
3·34	,,	9·34	,,	1·60 ,,
16·08	,,	·25	ash.	
13·71	,,	·20	,,	
13·87	,,	2·41	platinum salt.	
11·52	,,	·77	sulphate baryta.	

Caldwell and Thomson's Higher Delf.

This coal contained ·98 per cent. of water; dried at 212° Fah.

Coal.				
3·48	grs. gave	9·57	carbonic acid and	1·50 water.
3·45	,,	9·59	,,	1·52 ,,
9·09	,,	·54	ash.	
11·04	,,	·66	,,	
11·38	,,	2·56	platinum salt.	
11·96	,,	2·05	sulphate baryta.	

Haswell Wallsend.

This coal contained 4·08 per cent. of water: dried at 212° Fah.

Coal.				
2·97	grs. gave	9·13	carbonic acid and	1·89 water.
3·49	,,	10·64	,,	1·98 ,,
11·76	,,	·02	ash.	
12·83	,,	·03	,,	
13·14	,,	2·97	platinum salt.	
10·25	,,	·05	sulphate baryta.	

Livingstone's Steam Fuel.

This fuel contained 1·39 per cent. of water: dried at 212° Fah.

Fuel.				
3·28	grs. gave	10·33	carbonic acid.	
3·01	,,	9·52	,,	and 1·12 water.
12·94	,,	·60	ash.	
16·71	,,	·74	,,	
12·11	,,	3·48	platinum salt.	
12·18	,,	1·29	sulphate baryta.	

Machen Rock Vein.

This coal contained 2·50 per cent. of water: dried at 212° Fah

Coal.				
3·51	grs. gave	9·16	carbonic acid and	1·59 water.
3·58	,,	9·32	,,	1·53 ,,
10·81	,,	·42	ash.	
9·42	,,	·36	,,	
12·28	,,	1·87	platinum salt.	
12·08	,,	1·21	sulphate baryta.	

Haydock Rushy Park.

This coal contained 1·89 per cent. of water: dried at 212° Fah.

Coal.				
3·10	grs. gave	8·77	carbonic acid and	1·58 water.
3·36	,,	9·63	,,	1·69 ,,
15·74	,,	·58	ash.	
12·48	,,	·46	,,	
12·81	,,	1·02	platinum salt.	
9·58	,,	1·21	sulphate baryta.	

Haydock Little Delf.

This coal contained 3·19 per cent. of water: dried at 212° Fah.

Coal.				
3·42	grs. gave	9·97	carbonic acid and	1·62 water.
3·31	,,	9·70	,,	1·51 ,,
18·66	,,	·63	ash.	
17·20	,,	·60	,,	
15·58	,,	1·36	platinum salt.	
14·93	,,	·78	sulphate baryta.	

Haydock Higher Florida.

This coal contained 6·12 per cent. of water: dried at 212° Fah.

Coal.				
3·38	grs. gave	9·61	carbonic acid and	1·67 water.
3·61	,,	10·21	,,	1·84 ,,
20·34	,,	·64	ash.	
20·24	,,	·60	,,	
12·10	,,	1·95	platinum salt.	
13·30	,,	1·00	sulphate baryta.	

Haydock Main Florida.

This coal contained 6·61 per cent. of water: dried at 212° Fah.

Coal.				
3·70	grs. gave	10·45	carbonic acid and	1·75 water.
3·39	,,	9·69	,,	1·76 ,,
12·87	,,	·26	ash.	
11·35	,,	·23	,,	
14·04	,,	2·84	platinum salt.	
14·56	,,	·94	sulphate baryta.	

Vivian and Sons' Mirfa Four Feet.

This coal contained 0·63 per cent. of water: dried at 212° Fah.

Coal.				
3·44	grs. gave	10·42	carbonic acid and	1·60 water.
3·50	,,	10·64	,,	1·72 ,,
13·30	,,	·71	ash.	
13·00	,,	·69	,,	
11·51	,,	1·91	platinum salt.	
9·43	,,	·66	sulphate baryta.	

Vivian and Sons' Rock Vawr.

This coal contained 1·45 per cent. of water: dried at 212° Fah.

Coal.				
3·54	grs. gave	10·25	carbonic acid and	1·73 water.
3·41	,,	9·91	,,	1·53 ,,
10·83	,,	·46	ash.	
13·75	,,	·60	,,	
13·41	,,	1·41	platinum salt.	
11·12	,,	1·96	sulphate baryta.	

South Cape, V.D.L.

This coal contained 3·33 per cent. of water: dried at 212° Fah.

Coal.				
3·89	grs. gave	9·04	carbonic acid and	1·03 water.
4·36	,,	10·14	,,	1·12 ,,
12·56	,,	3·82	ash.	
11·64	,,	3·55	,,	
12·83	,,	3·46	platinum salt.	
13·54	,,	·97	sulphate baryta.	

Mount Nicholas, Break o' Day.

This coal contained 7·24 per cent. of water: dried at 212° Fah.

Coal.				
4·14	grs. gave	8·71	carbonic acid and	1·45 water.
4·28	,,	9·01.	,,	1·52 ,,
11·60	,,	3·08	ash.	
14·31	,,	4·17	,,	
14·43	,,	2·66	platinum salt.	
13·32	,,	1·19	sulphate baryta.	

Fingal, V.D.L.

This coal contained 4·86 per cent. of water: dried at 212° Fah.

Coal.				
3·91	grs. gave	8·21	carbonic acid and	1·18 water.
3·63	,,	7·61	,,	1·12 ,,
10·60	,,	3·08 ash.		
14·31	,,	4·17 ,,		
12·60	,,	2·41 platinum salt.		
12·32	,,	1·19 sulphate baryta.		

Jerusalem, V.D.L.

This coal contained 3·06 per cent. of water: dried at 212° Fah.

Coal.				
3·93	grs. gave	9·86	carbonic acid and	1·42 water.
4·89	,,	12·18	,,	1·75 ,,
15·09	,,	2·92 ash.		
16·52	,,	3·15 ,,		
15·62	,,	4·05 platinum salt.		
12·92	,,	1·06 sulphate baryta.		

Douglass River, East Coast, V.D.L.

This coal contained 4·87 per cent. of water: dried at 212° Fah.

Coal.				
4·05	grs. gave	10·48	carbonic acid and	1·51 water.
4·06	,,	10·47	,,	1·56 ,,
12·50	,,	1·82 ash.		
13·20	,,	1·88 ,,		
14·85	,,	2·64 platinum salt.		
15·63	,,	·80 sulphate baryta.		

Tasman's Peninsula, V.D.L.

This coal contained 4·40 per cent. of water: dried at 212° Fah.

Coal.				
4·69	grs. gave	11·32	carbonic acid and	1·42 water.
3·26	,,	7·80	,,	·98 ,,
20·20	,,	5·28 ash.		
13·82	,,	3·69 ,,		
12·23	,,	3·73 platinum salt.		
11·70	,,	·88 sulphate baryta.		

Schonten Island, V.D.L.

This coal contained 2·17 per cent. of water: dried at 212° Fah.

Coal.				
3·94	grs. gave	9·28	carbonic acid and	1·21 water.
3·43	,,	8·04	,,	1·14 ,,
12·54	,,	3·42 ash.		
15·07	,,	4·08 ,,		
14·96	,,	2·10 platinum salt.		
12·87	,,	·80 sulphate baryta.		

Whale's Head, South Cape, V.D.L.

This coal contained 1·72 per cent. of water: dried at 212° Fah.

Coal.				
3·05	grs. gave	7·35	carbonic acid and	·85 water.
3·14	,,	7·60	,,	·93 ,,
10·90	,,	2·34 ash.		
10·81	,,	2·33 ,,		
15·40	,,	2·75 platinum salt.		
13·06	,,	1·10 sulphate baryta.		

Adventure Bay, V.D.L.

This coal contained 3·84 per cent. of water: dried at 212° Fah.

Coal.				
3·48	grs. gave	10·17	carbonic acid and	·92 water.
3·31	,,	9·80	,,	·95 ,,
14·56	,,	1·28 ash.		
16·57	,,	1·42 ,,		
12·23	,,	2·66 platinum salt.		
12·68	,,	1·62 sulphate baryta.		

Lignite, Trinidad.

This coal contained 12·62 per cent. of water: dried at 212° Fah.

Coal.					
3·26	grs.	gave	7·88	carbonic acid and	1·33 water.
4·03	,,		9·53	,,	1·44 ,,
18·30	,,		1·19	ash.	
19·73	,,		1·42	,,	
16·53	,,		3·52	platinum salt.	
19·84	,,		1·01	sulphate baryta.	

Showing the Mean Composition of Average Samples of the Coals.

	NAME OR LOCALITY OF COAL.	Specific Gravity of Coals.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Per centage amount of Coke left by each Coal.
Welsh Coals.	Aberaman Merthyr	1·305	90·94	4·28	1·21	1·18	0·94	1·45	85·0
	Abercarn	1·334	81·26	6·31	·77	1·86	9·96	2·04	68·4
	Machen	1·297	71·08	4·88	·95	1·37	17·87	3·85	65·2
	Birch Grove Graigola	1·360	84·25	4·15	·73	·86	5·58	4·43	85·1
	Cadoxton	1·378	87·71	4·34	1·05	1·75	1·58	3·57	82·0
	Vivian and Sons' Mirfa	1·299	82·75	5·31	1·04	·95	4·64	5·31	67·1
	Brymbo Main	1·300	77·87	5·09	·57	2·73	9·52	4·22	55·4
	Vivian and Sons' Rock Vawr	1·301	79·09	5·20	·66	2·41	8·34	4·30	58·6
	Brymbo Two Yard	1·283	78·13	5·53	·54	1·88	8·02	5·90	56·2
Newcastle Coals.	Willington	..	86·96	4·95	1·05	·88	5·12	1·04	..
	Bowden Close	..	84·92	4·53	·96	·65	6·66	2·28	..
	Haswell Wallsend	1·286	83·47	6·68	1·42	·06	8·17	0·20	62·7
	West Hartley Main	1·264	81·85	5·29	1·69	1·13	7·53	2·51	59·2
Lancashire Coals.	Ince Hall Co.'s Arley	1·272	82·61	5·86	1·76	·80	7·44	1·53	64·0
	Haydock Little Delf	1·257	79·71	5·16	·54	·52	10·65	3·42	58·1
	Ince Hall Pemberton Yard	1·348	..	..	..	..	..	..	60·6
	Haydock Rushy Park	1·323	77·65	5·53	·50	1·73	10·91	3·68	59·4
	Moss Hall Pemberton Four Feet	1·258	75·53	4·82	2·05	3·04	7·98	6·58	55·7
	Haydock Higher Florida	1·218	77·33	5·56	1·01	1·03	12·02	3·05	51·1
	Ince Hall Pemberton Four Feet	1·276	77·01	3·93	1·40	1·05	5·52	1·09	57·1
	King	1·300	73·66	5·30	1·68	1·58	9·06	8·72	62·4
	Haydock Main Florida	1·267	77·49	5·50	1·27	·88	12·84	2·02	54·4
	Wigan Four Feet	1·209	78 86	5·29	·86	1·19	9·57	4·23	60·0
	Ince Hall Pemberton Five Feet	1·269	68·72	4·76	2·20	1·35	18·63	14·34	56·5
	Ince Hall Co.'s Furnace Vein	1·314	71·74	5·71	1·53	·96	13·52	4·04	58·4
	Caldwell and Thomson's Rushy Park	1·271	76·17	5·46	1·09	·91	14·87	1·50	58·7
	Moss Hall Pemberton Five Feet	1·283	76·16	5·35	1·29	1·05	10·13	6·02	56·1
	Moss Hall Co.'s New Mine	1·278	77·50	4·84	·98	1·36	12 16	3·16	57·7
	Caldwell and Thomson's Higher Delf	1·274	75·40	4·83	1·41	2·43	19·98	5·95	54·2
Derbyshire Coals.	Earl Fitzwilliam's Elsecar	1·296	81·93	4·85	1·27	·91	8·58	2·46	61·6
	Hoyland and Elsecar Co.'s	1·317	80·05	4·93	1·24	1·06	8·99	3·73	62·5
	Earl Fitzwilliam's Park Gate	1·311	80·07	4·92	2·15	1·11	9·95	1·80	61·7
	Butterly Co.'s Portland	1·301	80·41	4·65	1·59	·86	11·26	1·23	60·9
	Butterly Co.'s Langley	1·264	77·97	5·58	·80	1·14	9·86	4·65	54·9
	Loscoe Soft	1·285	77·49	4·86	1·64	1·30	12·41	2·30	52·8
	Coleshill Co.'s Bagilt Main	1·269	88·48	5·62	2·02	1·36	0·86	1·62	55·8
	Ewloe	1·275	80·97	4·96	1·10	1·40	8·20	3·37	54·5
	Ibstock	1·291	74·97	4·83	·88	1·45	11·88	5·99	50·8
Scotch..	Kilmarnock Skerrington	1·241	79·82	5·82	·94	·86	11·31	1·25	49·3
Patent Fuels.	Livingstone's Steam Fuel	1·184	86·07	4·13	1·80	1·45	2·03	4·52	..
	Hollands and Green's Patent Fuel	1·302	70·14	4·65	1·15	..	..	13·73	..
Foreign Coals.	South Cape	..	63·40	2·89	1·27	·98	1·01	30·45	..
	Mount Nicholas, Break o' Day	..	57·39	3·91	1·15	·90	9·10	27·55	..
	Fingal	..	57·21	3 38	1·20	1·32	7·80	29·09	.
	Jerusalem	..	68·18	3·99	1·62	1·12	5·89	19·20	..
	Douglass River, East Coast	..	70·44	4·20	1·11	·70	9·27	14·38	..
	Tasman's Peninsula	..	65·54	3·36	1·91	1·03	1·75	26·41	..
	Schonten Island	..	64·01	3·55	·94	·85	3·38	27 17	..
	Whale's Head, South Cape	..	65·86	3·18	1·12	1·14	7·20	21·50	..
	Adventure Bay	..	80·22	3·05	1·36	1·90	4·80	8·67	..
	Lignite, Trinidad	..	65·20	4·25	1·33	·69	21·69	6·84	..

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